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THESIS

WHOLESALE LEVEL REORDER POINT AND REORDER QUANTITY COMPUTATION DURING PERIODS OF DECLINING DEMAND

by

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December 1992

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For several decades the U.S. Navy has used a set of specific mathematical inventory models to help wholesale item managers make management decisions concerning consumable items of material. Implicit in these models is the assumption that the mean of quarterly demand for an item remains constant over time. This assumption is violated often, particularly during periods of force reduction or when equipment is retired. When this declining demand pattern occurs, the inventory models usually keep stock levels too high. This results in excess material known as "inapplicable" inventory.

Recently, inapplicable inventory in the Navy was estimated to be as high as 10.4 billion dollars. Navy logisticians have invested a great deal of effort in solving this problem, mainly by focusing on forecasting. While improved forecasting may reduce inapplicable inventory to some extent, it will not, by itself, solve the problem

This research has explored the problem of inapplicable inventory, its model-based causes and alternative solutions. The resulting inventory model, designed to work easily within the existing Navy UICP inventory information system, significantly reduced inapplicable inventory in several simulations which were run in this research.

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Wholesale Level Reorder Point and
Reorder Quantity Computation During
Periods of Declining Demand

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ABSTRACT

For several decades the U.S. Navy has used a set of specific mathematical inventory models to help wholesale item managers make management decisions concerning consumable items of material. Implicit in these models is the assumption that the mean of quarterly demand for an item remains constant over time. This assumption is violated often, particularly during periods of force reduction or when equipment is retired. When this declining demand pattern occurs, the inventory models usually keep stock levels too high. This results in excess material known as "inapplicable" inventory.

Recently, inapplicable inventory in the Navy was estimated to be as high as 10.4 billion dollars. Navy logisticians have invested a great deal of effort in solving this problem, mainly by focusing on forecasting. While improved forecasting may reduce inapplicable inventory to some extent, it will not, by itself, solve the problem.

This research has explored the problem of inapplicable inventory, its model-based causes and alternative solutions. The resulting inventory model, designed specifically to work easily within the existing Navy UICP inventory information system, significantly reduced inapplicable inventory in several simulations which were run in this research.

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I. INTRODUCTION

A. EXCESS INVENTORIES IN THE NAVY

Following the demise of the Soviet Union, the United States is facing a global environment requiring a new and, at this point, not clearly defined defense strategy. As the twentieth century comes to a close, many uncertainties face our nation. However, several decisions about the military's present and immediate future have been made by legislators and policy makers. The stagnant economy, social problems, and the national debt will be the issues receiving the highest priorities for government funding in the foreseeable future. The perception that a threat-free world environment exists has resulted in programmed reductions in the U. S. defense budget and the size of our military force. Many Navy weapon systems, created from the 1980's build-up, are no longer needed due to the reduced threat or replacement by new technology. In either case, many weapon systems have been or will be retired.

Many of the spare parts which supported retired weapon systems are categorized as inapplicable inventory. In the course of this research, it was difficult to establish an exact definition of inapplicable inventory. Inapplicable inventory was defined by VADM S. R. Arthur, Deputy Chief of Naval Operations for Logistics, as any stock on hand exceeding

two years worth of expected demand [Ref. 1]. Another source, NAVSUP Instruction 4500.13, defines inapplicable inventory as any stock on hand exceeding eight years worth of expected demand [Ref. 2:p. 1]. In either case, all units of an item having no expected future demand are categorized as inapplicable inventory. Government concern regarding excessive levels of inapplicable inventory in the Navy has been officially documented in several Government Accounting Office reports [Ref. 3, 4, & 5].

With much of the reduction in the size of the Department of Defense (DoD) expected to happen in the immediate future, the inventory models used by SPCC and ASO should be modified to handle the pending partial or complete retirement of many weapon systems. This thesis describes a model designed to work within the existing Navy wholesale inventory information system to compute reorder points and reorder quantities so that inapplicable inventory is significantly reduced in the future.

B. PRESENT MAGNITUDE OF INAPPLICABLE INVENTORY

1. INAPPLICABLE INVENTORY LEVELS

There are over 340,000 items categorized as having in excess of two years worth of expected demand in the Navy's supply system. Figure 1.1 displays the number of items having inapplicable inventory by Inventory Control Point and type of part (Depot Level Repairable versus Consumable) [Ref. 6:p. 3].

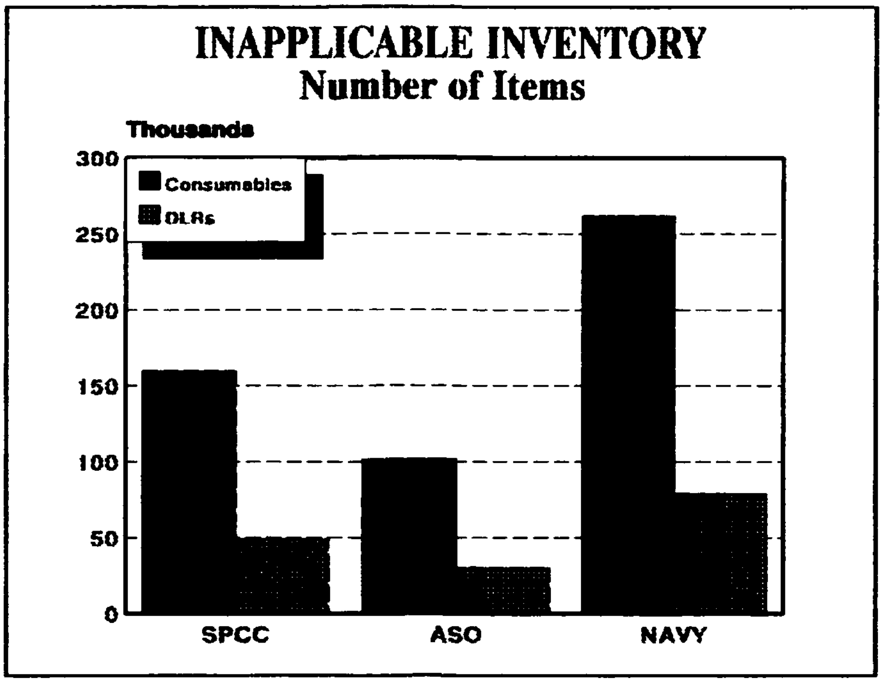

Figure 1.1 Inapplicable Inventory (Number of Line Items)

Figure 1.2 shows the dollar value of inapplicable inventory in the Navy supply system as of July 1990, by Inventory Control Point and part type [Ref. 6:p. 3].

Of the line items having inapplicable inventory in the Navy supply system, many no longer experience demand. Figure 1.3 displays, by number of line items, those inapplicable assets no longer experiencing demand, while Figure 1.4 shows the same information by dollar value [Ref. 6:p. 4].

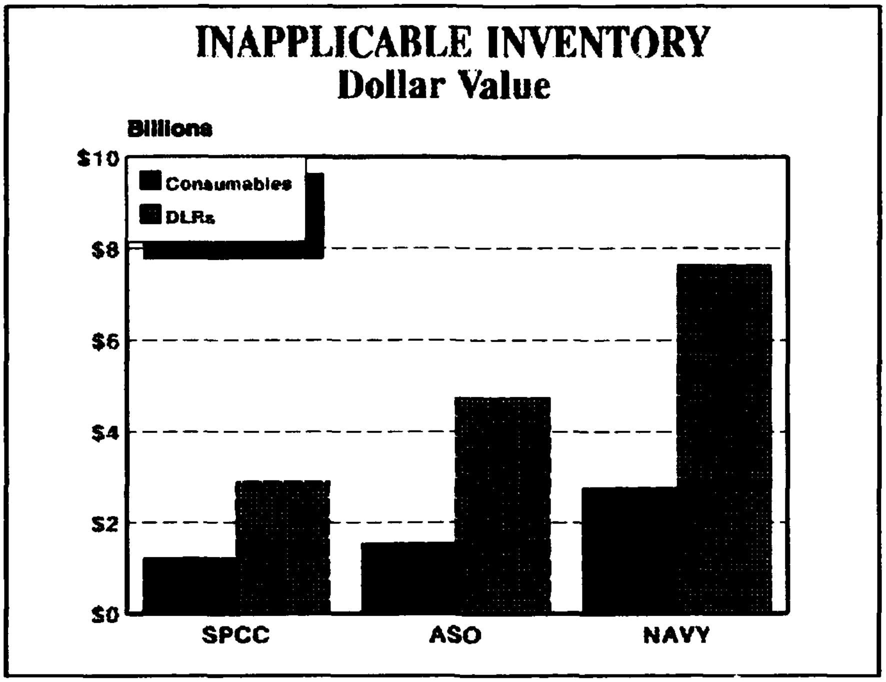

Figure 1.2 Inapplicable Inventory (Dollar Value)

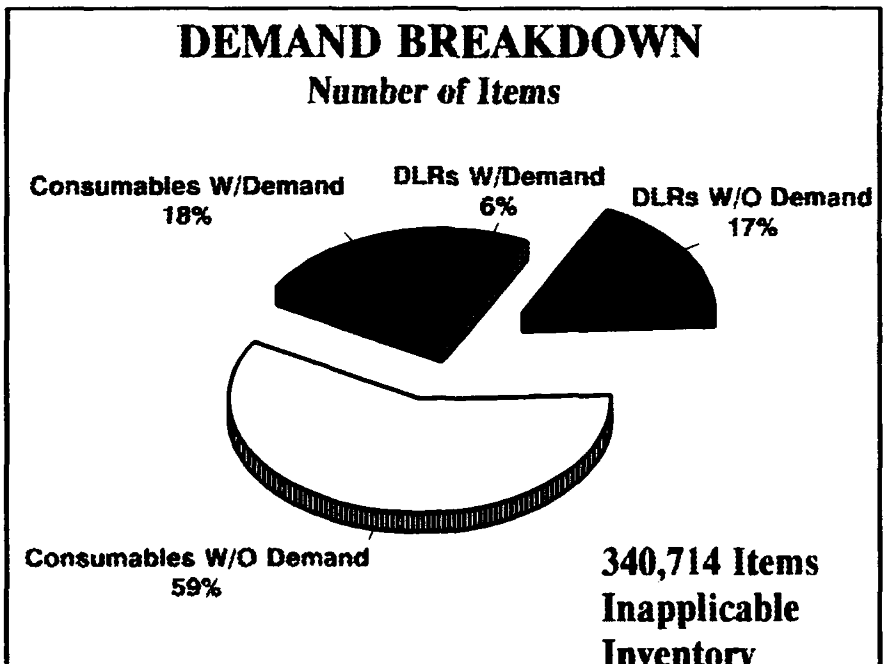

Figure 1.3 Inapplicable Inventory Demand Characteristics (Number of Items)

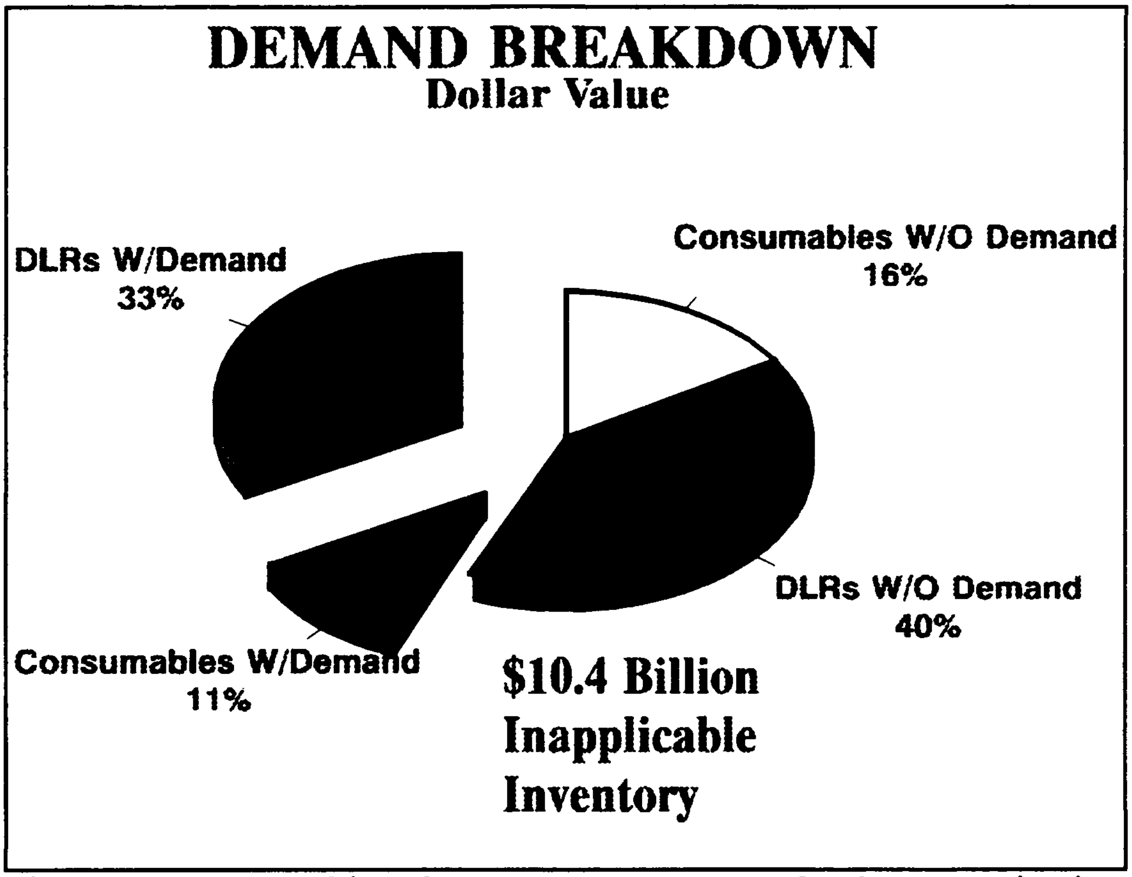

Figure 1.4 Inapplicable Inventory Demand Characteristics (Dollar Value)

2. ORIGINS OF INAPPLICABLE INVENTORY

There are two reasons why the retirement of assets and the resulting periods of declining demand cause the Navy's inventory model to create inapplicable inventory. First, reorder quantities and reorder points are calculated using demand forecasts computed from historical demand. The historical demand originates from a larger population of system assets and will result in reorder quantities and reorder points which will be too large. This can result in on-hand quantities which may never be used up. Second, in the

current Navy inventory models mean lead time demand is based on the assumption that mean demand is stationary. If mean demand declines during this period, the reorder quantity will most likely be too large to be used up. The nature of the computations in the UICP model and potential inapplicable inventory are discussed in Chapter III of this thesis.

C. OBJECTIVES AND SCOPE OF THE RESEARCH

The primary objective of this research is to explore and ultimately design modifications to the inventory models used at the Aviation Supply Office and Ships Parts Control Center. The resulting model, developed to work within the capabilities of the existing Navy computer systems, will reduce an item's reorder point and reorder quantity during periods of declining demand experienced as a result of equipment decommissioning and phase-out.

The scope of this research will be limited to the calculation of reorder points and reorder quantities for consumable items managed by ASO and SPCC. The resulting model will have application to items experiencing reduced demand due to system retirement or due to a planned reduction in the system population resulting from an engineering design change. The resulting model may be difficult to apply to a situation where an engineering design change results in a reduction in demand for an item due to less wear and tear on that item. In this case, the engineering design change may have too

uncertain an effect upon demand to have accurate forecasts of future demand which are needed for this model.

D. SUBSIDIARY RESEARCH AND METHODOLOGY

In order to develop the modification to the current models, it was necessary to determine how they calculate reorder point and reorder quantity for items used in equipment which is being retired. In addition, it was necessary to determine how and when item managers are notified of plans for the retirement of such equipment and how effective the current inventory models are in preventing inapplicable inventory. Also required was a close examination of the theoretical inventory models which have been previously developed to handle non-constant (non-stationary) demand.

Interviews with the Navy item managers were used to gather information about the problem of inapplicable inventory. Also required was analysis of several hypothetical inventory situations. In order to accomplish the necessary analysis of each of the hypothetical inventory problems, LOTUS 123 was used to generate various random demand patterns and test an inventory model designed to reduce inapplicable inventory. The resulting model is called the **Linear Q/R** inventory model.

E. DEFINITIONS AND ABBREVIATIONS

The following is a list of definitions and abbreviations for terms that are frequently used in this thesis:

- **Inapplicable inventory/Inapplicable assets** - The amount of excess stock that results when receipts of an item exceed what is required resulting in in-stock positions that exceed the demand for the material. A situation where this excess occurs is during periods of declining demand due to retirement of equipment. For inventory still experiencing demand, the inapplicable portion is that stock exceeding two years worth of demand. The entire inventory of items experiencing no demand is considered inapplicable.

- **Uniform Automated Data Processing System for Inventory Control Points (UICP)** - The wholesale inventory information system used by item managers at ASO and SPCC.

- **Cyclic Levels and Forecasting application** - Also known as "DO1" or "Levels". This is the specific software in UICP containing the models which forecast the demand and the procurement lead time, and also compute the reorder quantity and reorder point for an item.

- **Inventory Position (IP)** - The quantity in units-of-issue of an item that is on-hand in the wholesale supply system plus the number of units currently on-order with the manufacturer minus the total number of units promised to all customers of the wholesale inventory (this latter number is called the number of backorders).

- **Reorder Point (R)** - The inventory position at which an order for a particular quantity of an item is placed with the manufacturer.

- **Reorder Quantity (Q)** - The lot size placed with the manufacturer when the reorder point is reached.

F. SUMMARY OF FINDINGS

The following is a summary of the most important findings of this research:

- While improved forecasting will reduce inapplicable inventory to some extent, it will not, by itself, completely solve the problem of inapplicable inventory.

- The existing UICP model does not adjust adequately for declining demand and thus helps create the problem of inapplicable inventory.

- The inventory model developed in this research significantly reduced the amount of inapplicable inventory in the simulation series that were examined.
- In all of the simulation series examined in this research, Average Customer Wait Time (ACWT) was dramatically increased. However, performance of the Linear Q/R model, in terms of ACWT, can be improved by delaying the implementation of the model.

G. ORGANIZATION OF THE STUDY

This thesis consists of six chapters. Chapter II provides a literature review concerning pertinent theoretical inventory models and background literature on UICP. Chapter III provides an overview of the UICP "levels" software application, the origins of inapplicable inventory, and two cases examining efforts at the ICPs to prevent inapplicable inventory. Chapter IV examines a situation where the retirement of a population of identical weapon systems leads to a severe decline in the mean demand for a particular NSN. In this chapter, perfect forecasts are assumed to be available to the UICP inventory model, and the resulting amount of inapplicable inventory is estimated. Chapter V contains the ideas used in developing the Linear Q/R inventory model and an extensive series of simulations to evaluate the performance of the proposed inventory model in reducing inapplicable inventory during periods of declining demand. Chapter VI presents the summary, conclusions, and recommendations of this research.

II. LITERATURE REVIEW

A. INTRODUCTION

Our interest in the inapplicable inventory problem was stimulated by the complexity of the problem, along with the fact that no good solution to the problem exists. This interest led to research using materials obtained from the Dudley Knox Library at the Naval Postgraduate School, from the Fleet Material Support Office (FMSO)[1], and from other sources regarding the UICP inventory model. The remainder of this chapter describes the results of this literature review. Section B is devoted to the theoretical literature and Section C contains information regarding the Navy's present UICP inventory model.

B. THEORETICAL INVENTORY MODELS

There has been a large number of theoretical papers written on inventory models where mean demand is stationary. However, the resources pertaining to non-stationary demand are much more limited. Several of the most important of these latter papers are reviewed in the following paragraphs.

[1] FMSO is the central design agency (CDA) for the computer software used at the ICPs. FMSO has responsibility for the design of supply models and procedures.

The prominent issue in Silver's 1978 article [Ref. 7] is determining the timing and the sizes of replenishment for an item having probabilistic demand with a mean that varies significantly over time. Silver approached the problem from the standpoint of deciding when to order, the selection of a time period for the order to cover, and selecting reorder quantities and order-up-to-levels. Silver's approach to the computation of safety stock is very similar to that of the UICP inventory model in that he is concerned with:

- specified probability of no stockout per replenishment cycle
- specified fraction of demand to be satisfied routinely from stock.

A prominent issue in this thesis not covered in this article was the issue of demand that was declining in nature. Silver's approach in this article related only to mean demand that varied over time with no significant trend in that mean demand.

The primary theme of the 1980 Lev and Weiss and Soyster article [Ref. 8] is the anticipation of parameter changes for computational purposes. Their methodology divided a finite time horizon into two intervals. During the first interval, all parameters affecting inventory costs remained constant. Then at the start of the second interval, one or more parameters affecting inventory costs changed. This model assumes constant, deterministic demand in both intervals of the time horizon. The type of parameter changes that

dominated the examples in this paper involved price increases. Both the demand and pricing characteristics represent differences from the Linear Q/R Inventory model used in this research.

The origin of inapplicable inventory, in many cases, stems from a reduction in demand due to the retirement of weapon systems which reduces the population requiring support. Therefore, we examined several articles relating to inventory models that accommodate linear trends in demand. For example, Donaldson [Ref. 9] developed a model which assumes a linear trend in demand beginning at time zero and ending at the conclusion of a specified time horizon. He determined the optimal number and timing of replenishment over the entire time horizon. Unlike the UICP Inventory model, Donaldson's preference is to use the replenishment cycle (T) rather than replenishment quantity (Q) as a decision variable in for his model. Donaldson's preference for using a replenishment cycle (T) in his model stems from the assertion that the replenishment cycle approach "facilitates the classification of items into groups when the inventory situation involves a large number of items" [Ref. 9:p: 663].

Donaldson's article stimulated a modest body of follow-up research. In a 1984 article concerning linear increasing demand, Ritchie sought to simplify Donaldson's solution by examining changes in the optimal policy when the time horizon is extended [Ref. 10]. Ritchie succeeded in developing a

simpler model than Donaldson's which gave almost optimal results. In a closely related 1984 article, Mitre and Cox and Jessie attempt similar simplifications to Donaldson's method. They developed a process in which the intervals between orders are equal and the order quantities vary from period to period [Ref. 11]. Two articles, in 1985 and 1986, by Ritchie and Tsado determined that Donaldson's model could be applied to an unbounded (by a time horizon) linear increasing demand situation. They also determined that a simple economic order quantity computation for reorder quantities could be used with little cost penalty [Ref. 12 & 13].

The methodology contained in this series of articles focused on linearly increasing trends in demand. The opposite of the demand characteristics present in the problem of inapplicable inventory due to retirement of assets. Although, not directly applied in this thesis, the initiation of a time horizon divided into intervals, as applied by Donaldson and Lev and Weiss and Soyster, could be an effective initial approach to attempting to prevent inapplicable inventory in the case of declining demand.

Elements of the problem of time-varying demand are explored in the 1985 book by Silver and Peterson, Decision Systems for Inventory Management and Production Planning. Important characteristics and considerations of the problem include the development of demand forecasts, the selection of appropriate replenishment quantities and reorder points, and

the duration of the demand pattern [Ref. 14:p. 221-222]. Silver and Peterson explore a method for sizing the final replenishment quantity under probabilistic demand for a product being phased out [Ref. 14:p. 377-379]. Their decision rule establishes a final reorder quantity based on forecasted demand and a desired service level. Their examination involves a tradeoff between the costs of insufficient inventory and the costs of acquiring too much inventory if the total demand remaining is less than the inventory position. The decision rule stated in this case requires the determination of the size of one last order by ordering enough to cover the remaining demand plus some safety stock based on a desired level of service.

Many of the theoretical papers, discussed in the previous paragraphs provided insight into dealing with changes in demand. These insights included recognition of the importance of safety stock as pointed out by Silver [Ref. 7 & 14] and the significance of the timing of a parameter change such as demand as discussed by Lev and Weiss and Soyster, and Donaldson [Ref. 8 & 9]. The use of a time horizon loosely applies in the case of the Linear Q/R model developed in this research, although the Linear Q/R model is not based on replenishment cycle time. Since a goal of this research was to work as much as possible within the existing UICP Inventory

model, there was no direct application of any one of these theoretical models to the inventory problem studied in this research.

C. UICP INVENTORY MODEL

An examination of the economic order quantity inventory model contained in NAVSUP Publication 553, *Inventory Management*, was conducted. The reorder point process was reviewed along with the basic premise for the computation of safety stock [Ref. 1⁻ p. 36-41].

Policy concerning procurement cycles and safety levels of supply for the Navy's secondary items was established by OPNAV Instruction 4440.23 and DoD Instruction 4140.39 [Ref. 16 & 17]. The objective of the replenishment guidelines stated in these instructions is to:

> "To minimize the total of variable order and holding costs subject to a constraint on time-weighted, essentiality-weighted requisitions short."
> [Ref.17:p. 3]

Adjustments to the UICP inventory model require a complete understanding of the basic order quantity and reorder point computations and subsequent constraints on the solutions to the total variable costs equation. NAVSUP Publication 553 describes the computational methods and reasoning behind each constraint including constraints on the order quantities such as time limitations on the order quantity and shelf-life limitations on the order quantity. Also discussed are the

constraints on the reorder level which consider required safety levels, low limits and stockage objectives, and shelf-life [Ref. 15:p. 3-63 - 3-66, 3-A-14 - 3-A-19].

Shown on the following page is a mathematical description of the UICP inventory model using the following notation:

- **Q** - Reorder Quantity.
- **R** - Reorder Point.
- $\mathbf{Q^*}$ - The unconstrained reorder quantity.
- $\mathbf{Q_1}$ - The basic reorder quantity.
- $\hat{\mathbf{Q}}$ - The final constrained reorder quantity.
- $\mathbf{R^*}$ - The basic reorder level.
- $\hat{\mathbf{R}}$ - The constrained reorder point.
- **A** - Administrative order cost per order.
- **D** - Mean demand in units per quarter.
- **I** - Inventory holding cost rate; a cost in dollars per dollar-year.
- **C** - Unit cost.
- **E** - Military essentiality (worth).
- λ - Shortage cost of one requisition backorder for one year.
- **S** - Expected number of units per requisition.
- $\mathbf{K_0}$ - ICP set parameter designed to assure a minimum reorder quantity. Generally set to 0.
- **TVC** - Total variable cost.
- **P** - The probability of incurring backorders during procurement lead time.
- μ - Mean lead time demand.
- $\mathbf{P_1}$ - Constrained risk value.

- **H** - Shelf life in years.
- **F(R)** - The cumulative distribution function describing the behavior of the random variable representing lead time demand.
- **L** - Procurement lead time.
- **DL** - Mean lead time demand.
- **B(Q,R)** - Expected number of units backordered.
- **W** - Average requisition frequency.

The UICP inventory model has the following form:

$$\text{minimize} \quad TVC(Q,R) = \frac{4AD}{Q} + IC[R + \frac{Q}{2} - \mu + B(Q,R)] + \frac{B(Q,R)\lambda E}{S} \qquad (1.0)$$

subject to:

$$Q \geq 1 \qquad (1.1)$$

$$Q \geq K_0 D \qquad (1.2)$$

$$Q \leq 2D \qquad (1.3)$$

$$R \geq K_1 \qquad (1.4)$$

$$R \leq D(4H + L - K_0) \qquad (1.5)$$

$$Q \leq 4DH - \max[0, (\hat{R} - DL)] \qquad (1.6)$$

$$P \leq K_2 \qquad (1.7)$$

$$P \geq K_3 \qquad (1.8)$$

where:

- K_0 is a user specified constant. This constant is normally set to zero.
- K_1 is a user defined minimum reorder point. This constant is normally set to 0 or 1.

- K_2 is a user defined maximum risk. It typically is set between 0.35 and 0.99.
- K_3 is a user defined minimum risk. It is typically set between 0.01 and 0.15.

When solving this problem, the UICP system does not actually expend the computer time that would be necessary to find the optimal solution. The software stops short of optimality. To get an initial value for Q, UICP disregards the expected number of backorders (B(Q,R)/S) and uses the economic order quantity solution [Ref. 15:p. 3-A-15].

$$Q^{*}=\sqrt{\frac{8AD}{IC}} \tag{2.0}$$

Next the UICP system applies constraints 1.1, 1.2, and 1.3 to the result of equation 2.0. The resulting value is the basic reorder quantity (Q_1).

To obtain an initial value for R, the UICP system makes use of the optimality condition obtained by taking the partial derivative of TVC(Q,R) with respect to R and setting this equal to zero. The optimality condition says that R should be the smallest R such that [Ref. 15:p. 3-A-17]:

$$1-F(R)\geq\frac{DIC}{DIC+\lambda WE}=P$$

Note, however, that constraints 1.7 and 1.8 are applied to the

righthand side of this equality before it is used to obtain the initial value for R [Ref. 15:p. 3-A-16], i.e. first P_1 is obtained:

$$P_1 = \min[K_2, \max(P, K_3)]$$

Then R is obtained from finding the smallest R such that:

$$1 - F(R) \geq P_1$$

The actual mechanics used by the UICP system to find R from this condition vary depending on the functional form of F(R). For example, if F(R) is a Normal probability distribution function, then the value for the normal deviate, z, is found from the appropriate table of the standard Normal distribution. R is then calculated using [Ref. 15:p. 3-A-17]:

$$R^* = \mu + z\sigma$$

Finally constraints 1.4, 1.5, and 1.6 are then applied to obtain the final constrained reorder point $\hat{R}$ and reorder quantity $\hat{Q}$ [Ref. 15:p. 3-A-16 - 3-A-18].

The UICP inventory model design specifications along with system functions are described in the Functional Description (FD) published by the Fleet Material Support Office [Ref.18]. Formulas supporting the UICP inventory model are contained in the FD along with decision guidance regarding the choice of distribution for lead time demand [Ref. 18:App. O and App. N].

III. UICP OVERVIEW AND EFFECT ON INAPPLICABLE INVENTORY

A. INTRODUCTION

Not all consumable items used by the Navy will be transferred to the Defense Logistics Agency (DLA) for wholesale inventory management. The Navy expects to retain about 0.5 million of the 2.9 million stock numbered consumable items it uses. Most of the Navy management of these items will be done at Ships Parts Control Center (SPCC) or the Aviation Supply Office (ASO).

The item managers who work at these ICPs have used a mathematical inventory model for several decades to help them pick the reorder point and reorder quantity for each NSN. While there are some exceptions, the normal procedure for an NSN is to run the model at the end of each quarter, based on the most recent forecasted quarterly demand and forecasted lead time for the NSN. Most of the time, the item manager will accept the recommended reorder point and reorder quantity from the model and will use them for the next three months in the control of the item (i.e., to determine when to start the buying process and how much to buy).

The previous chapter described the inventory model used by the item managers. Implicit in that model is the assumption that the mean of the quarterly demand for an item remains

constant over time. This assumption is violated often, particularly during periods of force reduction or when equipment is retired. When this latter declining demand pattern occurs, the inventory models usually keep stock levels too high. Navy logisticians have recently invested a great deal of effort in solving this problem. However, their focus has been mainly on forecasting. While improved forecasting may reduce inapplicable inventory to some extent, it will not, by itself, completely solve the problem.

B. THE ICP INVENTORY INFORMATION SYSTEM

The wholesale inventory information system used by item managers at ASO and SPCC is called the Uniform Automated Data Processing system for Inventory Control points (UICP). One of the functions performed by the 1.2 million lines of software code in the UICP system is the running of the mathematical inventory model described in the previous chapter.

The specific part of UICP that contains this inventory model is referred to as the Cyclic Levels and Forecasting application (also called "D01" or "Levels"). As the name indicates, this software forecasts various system parameters, such as the demand and the procurement lead time. It also computes the reorder quantity and reorder point for an item.

1. DEMAND AND LEAD TIME FORECASTING

The UICP Levels software generally uses single exponential smoothing to forecast quarterly demand and

procurement lead time. As a forecasting technique, single exponential smoothing works best when seasonal fluctuations or trends aren't present in the data. Exponential smoothing is reactive in the sense that it lags behind events that occur in the data. If seasonal fluctuations or trends are present, this lag problem increases substantially.

To partly compensate for the lag problem when a trend is present, the Levels software includes procedures for detecting upward or downward trends, and for detecting step changes in the data (i.e., huge increases or decreases in the data). However, until these procedures were recently revised, they were frequently inaccurate, often detecting non-existent trends, and sometimes failing to detect step changes. The recent revisions to these procedures have substantially improved their reliability.

It should be noted, however, that the revised trend detection procedures still produce a reactive forecast. There is still a significant lag problem. More importantly, the current forecasting procedures produce a forecast that applies only to the next period (i.e., next calendar quarter), because that's all that the inventory models call for. (All future quarters are assumed to have the same mean demand.)

2. INVENTORY CONTROL PROCESS FOR NAVY CONSUMABLE ITEMS

For each consumable item, the UICP inventory information system constantly keeps track of a quantity called

the inventory position (IP). The task of tracking IP requires the Navy ICPs to get data about the issuance of material to customers, receipt of orders from the manufacturer, and the placement of orders with the manufacturer.

When the IP value drops down to or below the reorder point (R), an order is placed with the manufacturer for Q+(R-IP) units, where Q is the reorder quantity computed by the inventory model (i.e., $\hat{Q}$ from the previous chapter), and R-IP is the number of units that the inventory position is currently below the reorder point. A procurement lead time later, the material arrives and is placed in storage. Since the length of the lead time for this order and the actual demand over that time cannot be known with certainty ahead of time, the model provides for an addition cushion, known as safety stock, in the calculation of R in hopes that the order will arrive before the inventory of the items is depleted.

C. THE PROBLEMS

There are two reasons why UICP is not capable of effectively handling non-homogeneous demand effectively. First, its forecasts lag behind real demand during periods of declining demand, causing Q and R to be too high which, in turn, results in excess material at the end of the decline period. This is true because Q and R are re-computed using demand forecasts that include previous demand levels from the larger population. If the decline in demand is steep enough,

the quantity on-hand (which may be as large as the most recent value of Q+R) may never be used up, and may thus end up as inapplicable inventory.

The second reason why UICP is not capable of effectively handling non-homogeneous demand is due to the assumption of constant mean demand over lead time made in the computation of Q and R. However, resupply can take two or three years for consumables. If the mean demand declines during the procurement lead time, the lot size and reorder points are no longer valid when the order does arrive. When this occurs, the lower demand levels at the time of material receipt will, in most cases, be insufficient to consume Q and the excess from the reduction in R.

From the discussion presented above, it can be inferred that improved forecasting techniques may reduce excess inventory resulting from forecast lags. However, these improvements can be expected to be much less effective in correcting excesses caused by decreasing demand during lead time.

D. PRESENT ICP SOLUTIONS

1. SPCC FORECASTING METHOD

SPCC's efforts to prevent inapplicable inventory have centered on attempts to adjust the system-wide forecasts for material installed on ships that are scheduled for decommissioning. To accomplish these adjustments, the most

recent two years of demand data for from ships scheduled for decommissioning is extracted from the Combat Logistics File.[2] Next, system-wide demand data for equipments installed in these ships extracted from the Inventory History File for the same period.[3] A ratio of decommissioned unit demand to total system demand is developed and used to reduce demand forecasts for associated equipment in anticipation of the subsequent decline in demand after the decommissioning takes place.

The test cases evaluating the effectiveness of these forecast adjustments are not yet available from SPCC, but it is important to note that this method is entirely based upon adjusting the forecast for an item. No adjustments are made to the reorder quantity/point since D01 will incorporate the adjusted forecast in the next running of "Levels" by the UICP. For further details on the forecasting adjustments used by SPCC when decommissioning is scheduled to occur, see Chapter III of Jackson's thesis [Ref. 19].

2. ASO FORECASTING METHOD

ASO forecasts demand for many of the items they manage based on the programmed flight hours of the aircraft which

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[2] The Combat Logistics File is considered best for this data since it contains demand data for specific ships. This data is compiled from various sources such as tenders, CLF ships, and stock points.

[3] The Inventory History File is used for total demand since it contains data for wholesale demand and some shore activities not contained in the combat logistics file.

contain the item, and an estimate of the failure rate per flight hour for the item. They have done some limited testing of a method for reducing inapplicable inventory by reducing forecasts for an item based on planned reductions in these the programmed flight hours. These reduced forecasts are then used in the UICP model for quarterly computation of Q and R.

This method for reducing inapplicable inventory is based entirely upon forecasting with no other anticipatory adjustments to the reorder quantity and reorder point. Figure 3.1 displays flight hour and inventory position data for a repair part from an A-7 aircraft[4]. In the graph, programmed hours were reduced by almost 50% over 8 quarters beginning in June of 1990. However, the inventory position was reduced by only 10% despite the reductions in the demand resulting from the reduced flight hours.

Jackson addresses the ASO process in Chapter IV of her thesis [Ref. 19]. Jackson describes the major weakness of the ASO process as heavy reliance upon an estimated failure rate. This failure rate estimate is based upon historical demand and is easily influenced by the variability of demand.

[4]Data for NSN 1RM 2995-00-740-1745, engine housing cover for A-7 aircraft, obtained from ASO Consolidated Stock Status Report from June 1992.

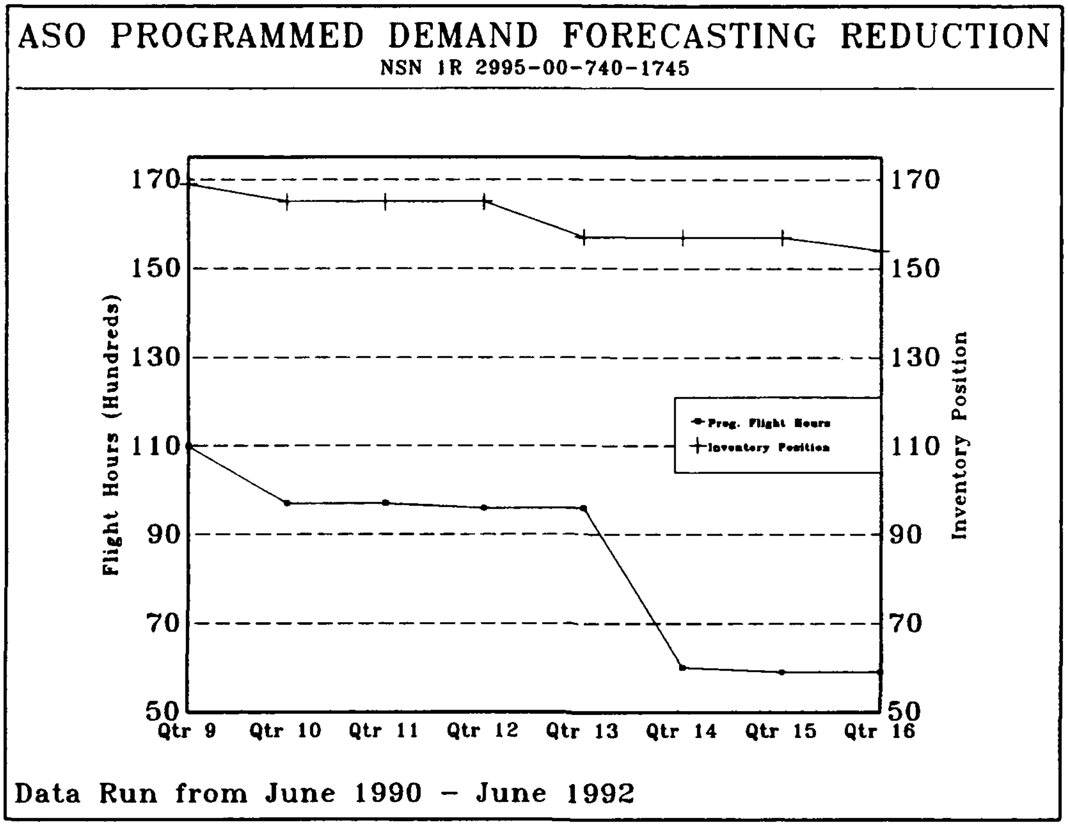

Figure 3.1 ASO Programmed Demand Forecast Reduction.

IV. UICP PERFORMANCE ASSUMING PERFECT FORECASTING

To demonstrate the impact of declining demand patterns on the performance of the UICP inventory model, it is useful to isolate the effect by eliminating all forecasting errors. This can be easily done in an experiment by assuming perfect knowledge of the simulated future demand series and setting the forecast for each quarter equal to the actual demand for that quarter. In this experiment, Q and R for each period are computed based on these perfect forecasts. Any excess inventory resulting from such an experiment can be assumed to be the result of the inventory model's inability to effectively deal with declining mean demand.

A. COMPUTER SIMULATION

In order to study the effect outlined above, we developed a computer simulation of the UICP inventory control system. The software was written in LOTUS 123 for Windows, version 1.1. This simulation approximates the inventory management of one consumable item over a ten year time period. The quarterly demand data is randomly generated according to an assumed Normal distribution. In addition, the simulation allows the user to specify system parameters, decision variables and an equipment decommissioning schedule.

While complete program documentation is provided in Appendix A, a brief explanation of the spreadsheet organization and its basic functions is provided in the following paragraphs. First, in order to simulate actual demand patterns experienced by the Navy's ICPs, random demand data is generated using the uniform random number generator available in LOTUS. Because the Navy inventory control points assume that demand follows a Normal distribution for much of the inventory they manage, the uniform random numbers are applied to a Normal distribution that follows a user-defined mean and standard deviation. The "Box-Muller" method is used to transform the uniform random numbers into Normally distributed random numbers. [Ref. 20:p. 566].

Next, a decline in the mean of the demand pattern is introduced by establishing a user-defined decommissioning schedule for the equipment in which the repair part is installed. The associated demand value is computed by multiplying the original simulated random demand value by the percentage of the population remaining at the start of the quarter in question. (The decommissioning is assumed to occur instantaneously at the start of the quarter.) The forecast for each quarter is then set equal to this reduced demand value (a perfect forecast). The spreadsheet then uses these perfect forecasts to compute values for Q and R using a LOTUS 1-2-3 version of the UICP inventory model developed by Moore

[Ref. 21] This process is followed for 40 quarters of simulated time.

Inventory position is computed by the spread sheet at the end of each quarter and, as noted in Chapter III, is equal to the amount of stock on hand plus outstanding orders, minus any backorders in the system. UICP performance in this experiment is measured in units of stock remaining at the end of quarter 40. Because the experiments performed in this research completely eliminate demand for the material by the end of the decommissioning period, the ideal ending inventory position should be zero. Inventory remaining at the end the 40th quarter is therefore considered to be excess. The greater the excess the worse the model's performance.

1. DATA RUNS

To begin testing UICP performance under perfect forecasting, we considered a hypothetical consumable circuit card that is managed at the wholesale level by SPCC. It is assumed that this circuit card is part of a hypothetical shipboard computer system that is used in the Combat Information Center (CIC) of 100 Navy ships. Five units of this circuit card are installed in each computer system aboard ship (total world wide population for the card is 500). Nearly all of the wholesale level demand for this circuit card originates with the failures that occur among these 500

installed circuit cards[5] (a negligible number of the demands at the wholesale level result from damage or loss either in-transit, in storage, or from factory defects).

2. INPUT PARAMETER VALUES

For the purposes of this simulation, UICP system parameters will be set to the values shown below and these values will remain constant from quarter to quarter:

- The holding cost rate per year is 23% of the unit cost of the circuit board.
- The unit cost is $500.
- The administrative cost of placing an order with the manufacturer is $740 per requisition per year.
- The shortage cost is $1000 per unit.
- The minimum risk constraint value is 0.1.
- The maximum risk constraint value is 0.35.
- The item manager has designated no policy receivers.[6]
  The essentiality value for the item is 1.
- The low limit for the reorder point is 1.
- Average requisition size is 4.2 units.
- Discount quantity is 0.
- The shelf life is 9999 yrs.
- The probability break point is 0.
- Baseline mean quarterly demand is 310 units.
- Baseline standard deviation of demand is 30% of mean quarterly demand.

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[5] Note that it isn't always possible for SPCC or ASO to clearly identify the source of the demand for the items they manage. Some circuit cards, for example, may be used in a dozen different kinds of computer systems and maintenance test equipment installed both aboard ships and at shore facilities. The population of installed circuit cards that are subject to failure may thus be constantly changing and so constantly affecting the overall quarterly demand.

[6] A policy receiver is a stock point chosen by the item manager to receive stock of the item from the manufacturer regardless of the level of demand received for the item by that stock point. The item manager has the freedom to designate no policy receivers or to designate all stock points as policy receivers or to do anything in between.

- Baseline procurement lead time is 7 quarters.
- Baseline decommissioning length is 8 quarters.

Also, as mentioned above we will assume that the probabilistic behavior of lead time demand is best described by the Normal distribution.

B. DATA SETTINGS AND RESULTS

In the perfect forecasting experiment, mean absolute deviation (MAD) for demand was set at zero for all quarterly computations. The initial amount of material on-hand (OH_0) was set equal to one half of the initial Q plus the initial safety stock (SS_0). (Both Q and SS_0 were obtained from the UICP model using the mean demand setting for the specific simulation run.)

$$OH_0 = \left(\frac{Q_0}{2}\right) + SS_0$$

The number of outstanding orders at the start of the simulation were set equal to the integer value of mean lead time demand (LTD) divided by the reorder quantity (Q_0), rounded down. The total number of units on order was then the product of this number of outstanding orders and the reorder quantity (Q_0).

$$OO_0 = \left[\frac{LTD}{Q_0}\right]^- (Q_0)$$

The inventory position for period 0 (the initial period) was set equal to the inventory on-hand (OH) plus on-order (OO), (i.e., we assumed there were no backorders at the start of quarter 1.)

For the purposes of this study, one complete simulation was run and the results were recorded in the following manner. Given the initial settings and a pseudorandom sequence of quarterly demand data, the spreadsheet computes the inventory position at the end of each quarter, placing orders for an amount Q of material when the inventory position drops below the reorder point. This process is continued to the end of quarter 40. The remaining inventory position is then recorded as a measure of the UICP model's performance for the run. This cycle is repeated ten times using a different pseudorandom sequence of demand data for each repetition, while holding all system parameters constant.

In order to study the effects of different system parameter settings, we conducted several sensitivity analyses. In the simulation runs described below, key parameters were varied to test their effect on UICP performance. For the seven perfect forecasting simulation series, all parameters were held constant at the baseline values with the exception of the variations for each run listed below:

- Varying mean quarterly demand while holding standard deviation of quarterly demand at 30% of mean quarterly demand and using a short decommissioning period. (4 quarters)

- Varying mean quarterly demand while holding standard deviation of quarterly demand at a constant percentage of mean quarterly demand and using a long decommissioning period. (12 quarters)

- Varying mean quarterly demand while using a low percentage of mean quarterly demand as the standard deviation of quarterly demand. (10%)

- Varying mean quarterly demand while using a high percentage of mean quarterly demand as the standard deviation of quarterly demand. (50%)

- Varying procurement lead time while using a short decommissioning period. (4 quarters)

- Varying procurement lead time while using a long decommissioning period. (12 quarters)

- Varying length of the decommissioning period from four to 14 quarters.

For detailed results from each simulation series, see Appendix C.

1. PERFECT FORECASTING SIMULATION CASE #1

The first simulation series involves 6 simulation runs with mean demand increasing from 10 units per quarter to 510 units per quarter in six equal increments. For each simulation run, the standard deviation of quarterly demand was set at 30% of demand, procurement lead time was set at 7 quarters, and the decommissioning period was set at 4 quarters. Figure 4.1 displays the mean excess inventory generated by the UICP model at the end of the decommissioning period. Mean excess is computed by averaging the final

inventory position for each of the 10 runs made during the simulation. The upper and lower limits shown represent one standard deviation of quarterly demand above and below the amount of mean excess material. These limits are computed using the LOTUS sample standard deviation command @STDS. This command performs the calculation indicated in the equation below:

$$STDS=\sqrt{\frac{\sum(Excess\text{-}Mean\ Excess)^2}{(10-1)}}$$

In this experiment, the reorder quantities and reorder points calculated by the UICP inventory model resulted in excess inventory, with the amount of the excess increasing with higher levels of demand. The mean of the excess was essentially a linear function of the mean quarterly demand.

2. PERFECT FORECASTING SIMULATION CASE #2

The second simulation series examines a scenario similar to simulation #1, except that the length of the decommissioning period was increased to 12 quarters. Mean demand was again increased from 10 to 510 in six equal increments. Likewise, the standard deviation of demand was again set at 30% of mean quarterly demand and procurement lead time was set at seven quarters. Figure 4.2 displays the resulting excess inventory. As for Case #1, the UICP model calculated values of Q and R that resulted in excess

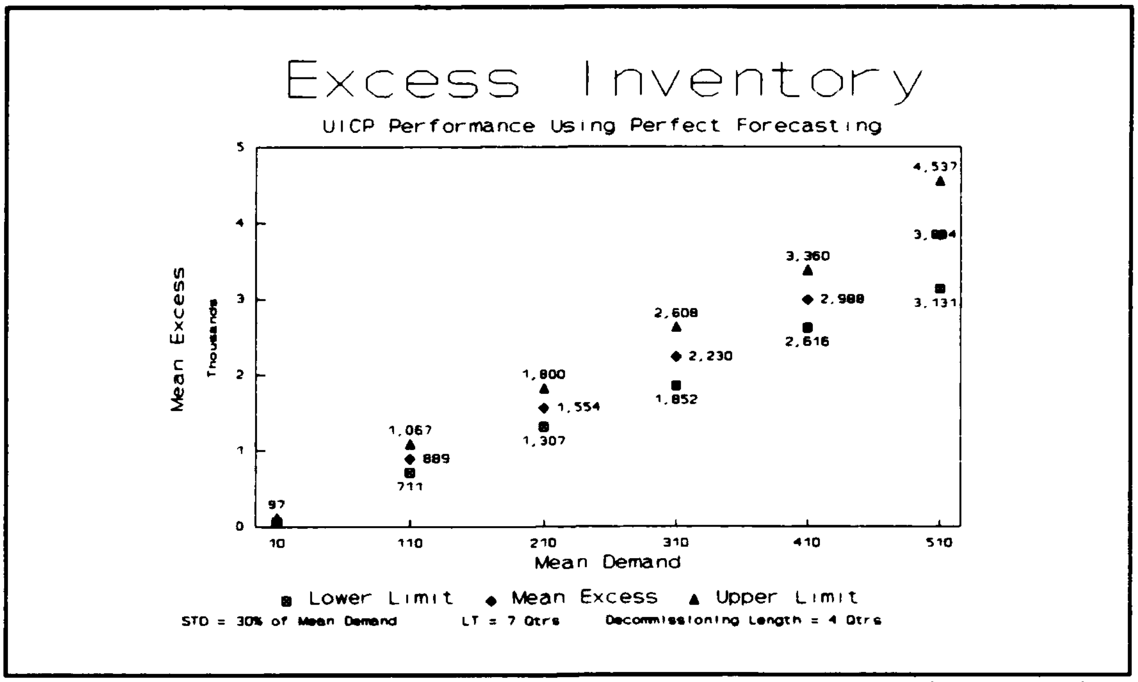

Figure 4.1 Perfect Forecasting Excess Inventory With Varying Mean Quarterly Demand and Short Decommissioning Period (Case #1).

inventory, but the overall excess is smaller than the amount experienced during a 4-quarter decommissioning cycle. This decrease in the amount of excess material is probably due to the longer decommissioning schedule. The change in mean demand that occurs during the procurement lead time is smaller under the longer decommissioning schedule. The longer decommissioning schedule therefore makes it easier for the UICP inventory model to adapt to the change in mean lead time demand. A greater portion of the inventory position present at the beginning of the decommissioning cycle can be used up and thus there would be a lower level of excess.

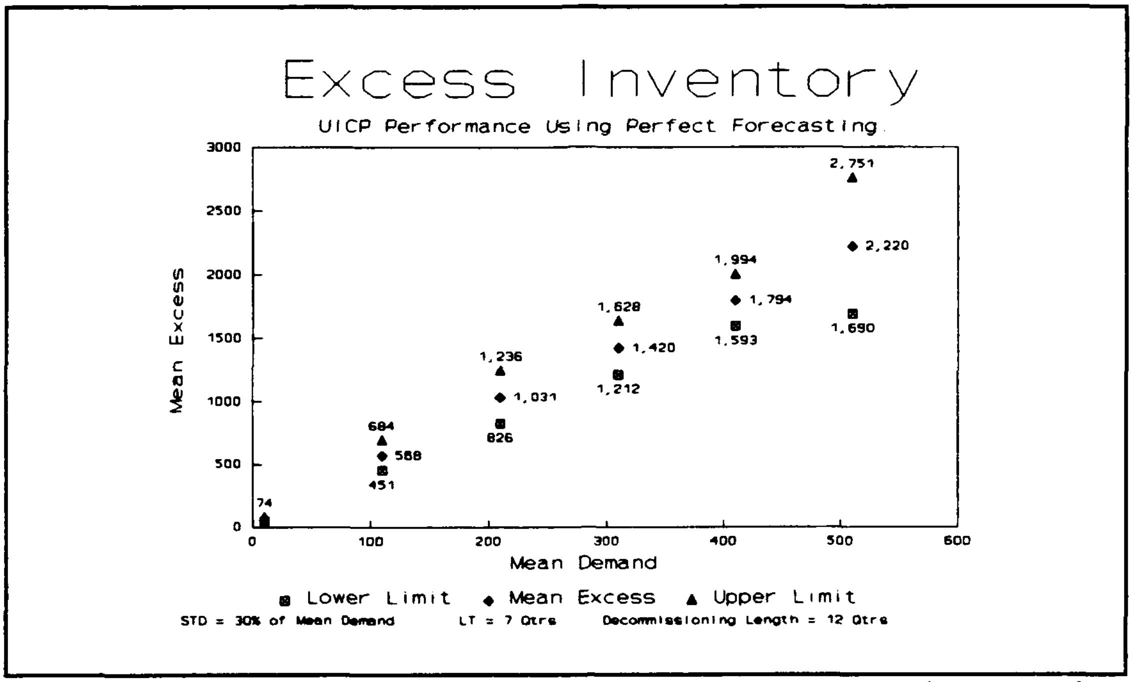

Figure 4.2 Perfect Forecasting Excess Inventory With Varying Mean Quarterly Demand and Long Decommissioning Period (Case #2).

3. PERFECT FORECASTING SIMULATION CASES #3 AND #4

The simulation runs for the third and fourth cases were designed to test the effect of demand variability on the UICP model's performance. The standard deviation of demand was set at 10% of mean quarterly demand in case #3 and at 50% of mean quarterly demand in case #4. The other parameter values for both simulations were as follows:

- mean quarterly demand was varied from 10 to 510 in six equal increments;
- procurement lead time was set to 7 quarters;
- decommissioning length was set to 8 quarters.

Figures 4.3 and 4.4 show the amounts of excess inventory generated by the UICP model in cases #3 and #4.

Once again, even with perfect forecasting, the model calculates values for Q and R that result in excess inventory. By comparing the results of the two cases, it can be seen that the amount of excess increases as the variability of demand increases.

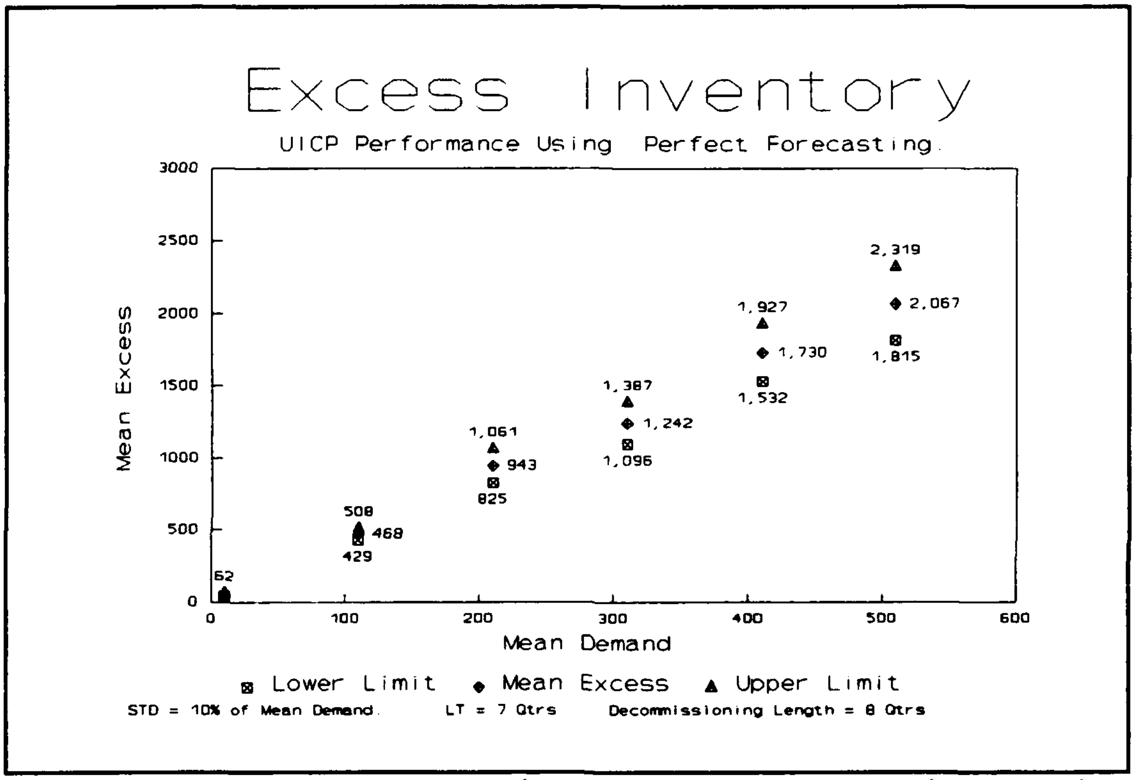

Figure 4.3 Perfect Forecasting Excess Inventory With Varying Mean Quarterly Demand and Low Variability of Quarterly Demand (Case #3).

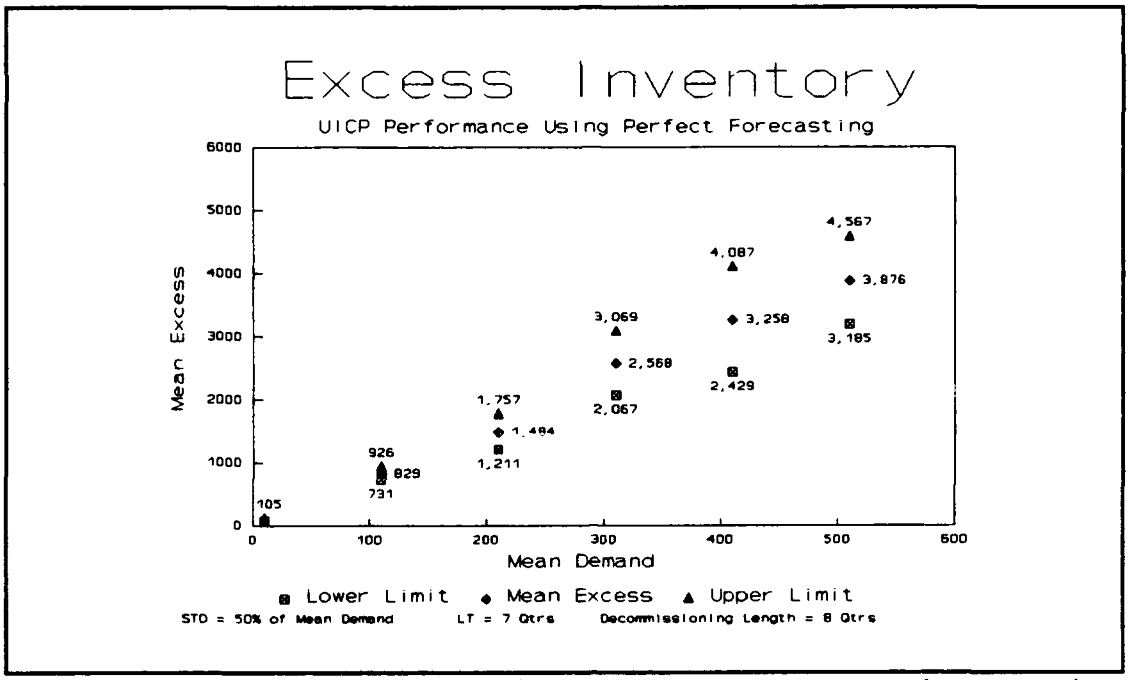

Figure 4.4 Perfect Forecasting Excess Inventory With Varying Mean Quarterly Demand and High Variability of Quarterly Demand (Case #4).

4. PERFECT FORECASTING SIMULATION CASE #5

This simulation cases examined the effect of increasing procurement lead time on the UICP model's performance with perfect forecasting and a relatively short decommissioning period. To do this analysis, lead time was increased from 2 to 12 quarters in increments of 2 quarters. For each simulation run, mean quarterly demand was set at 310 units per quarter and standard deviation set at 30% of mean quarterly demand. For this case, the decommissioning schedule was four quarters long. Figure 4.5 displays the amount of excess inventory generated at each level of procurement lead

time by UICP. The mean excess increases essentially linearly with procurement lead time.

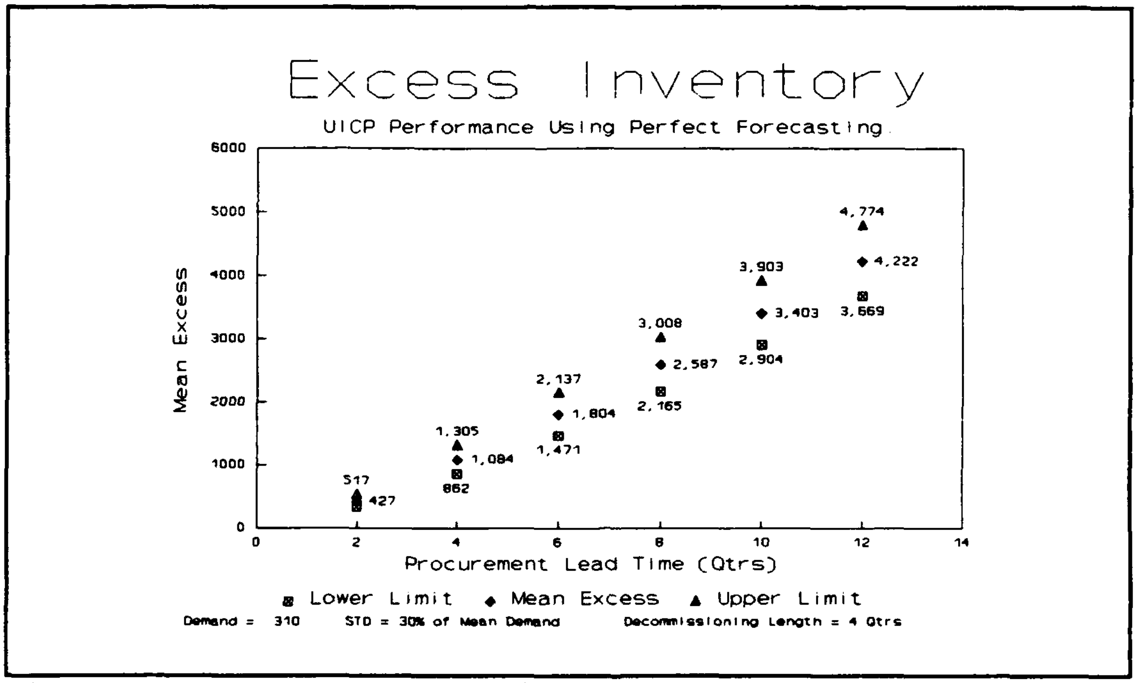

Figure 4.5 Perfect Forecasting Excess Inventory With Varying Procurement Lead Time and a Long Decommissioning Period (Case #5).

5. PERFECT FORECASTING SIMULATION CASE #6

The next simulation case was conducted to examine the effect of the procurement lead time on the UICP model's performance with perfect forecasting and a relatively long decommissioning period. To examine this effect, we used a decommissioning schedule length of 12 quarters and, as simulation Case #5, procurement lead time was varied from 2 to 12 quarters in 6 equal increments, mean quarterly demand was

set at 310 units per quarter and standard deviation set at 30% of mean quarterly demand. Figure 4.6 shows the excess inventory generated by the UICP model, with the mean excess increasing more than at a linear rate as procurement lead time increases. However, as expected, as the length of decommissioning schedule increases, the amount of excess material at the end of the decommissioning period decreases.

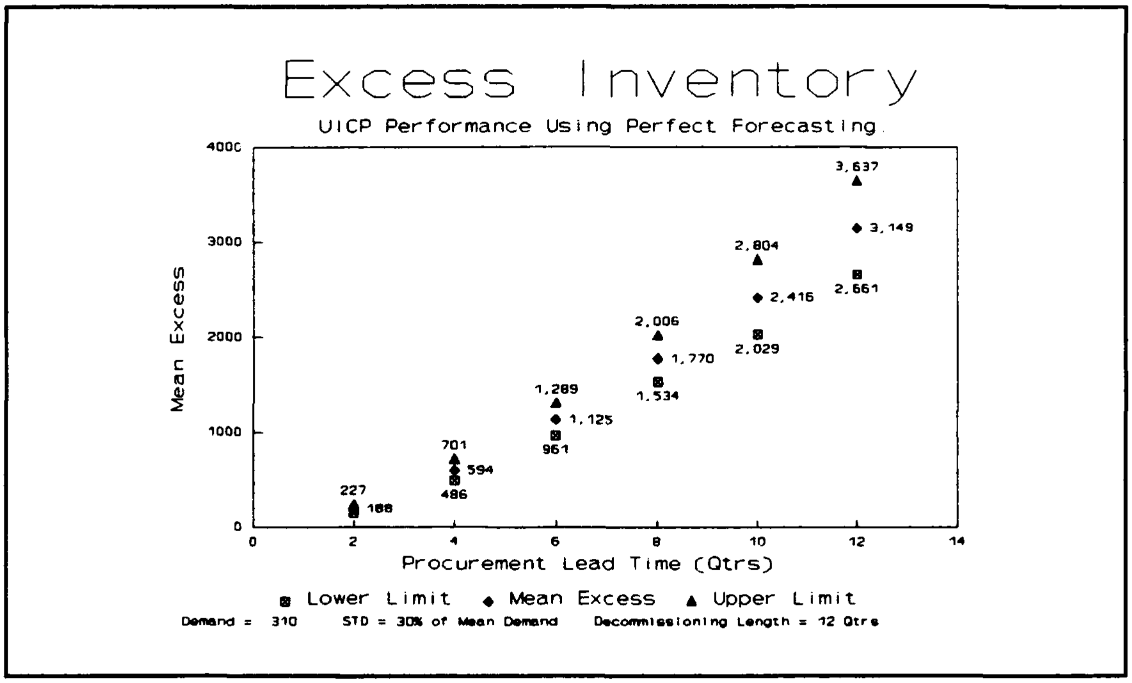

Figure 4.6 Perfect Forecasting Excess Inventory With Varying Procurement Lead Time and a Long Decommissioning Period (Case #6).

6. PERFECT FORECASTING SIMULATION CASE #7

In this final case, only the effect of increasing the length of the decommissioning schedule was examined. In this case, the length of the decommissioning period was increased from 4 quarters to 14 quarters in increments of 2 quarters.

Mean quarterly demand was set at 310 units per quarter, the standard deviation of quarterly demand was set at 30% of mean demand, and procurement lead time was set at 7 quarters. The resulting excess inventory is shown in Figure 4.7. The mean excess inventory decreases at a decreasing rate as the decommissioning period increases.

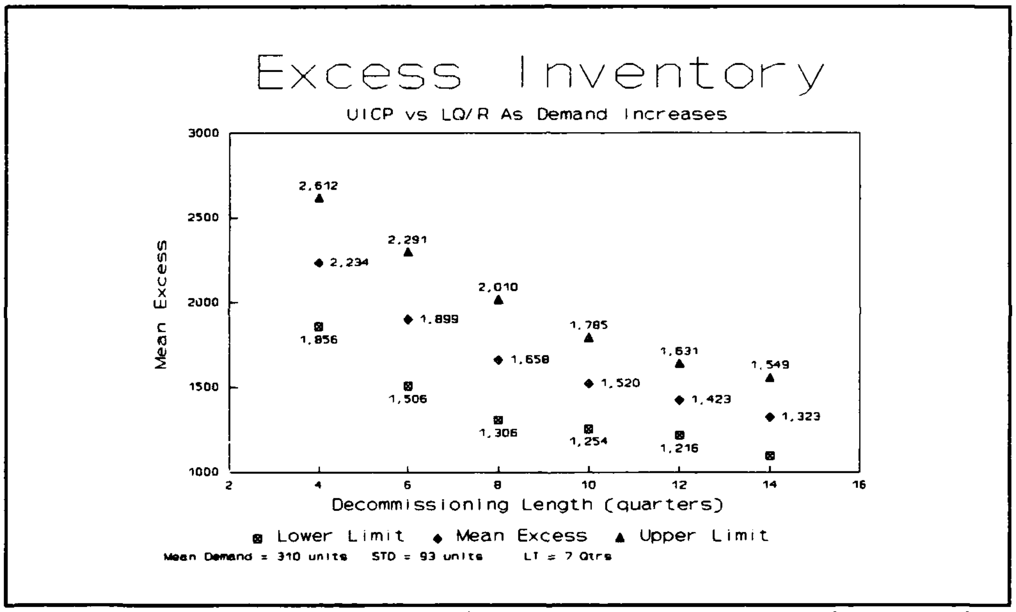

Figure 4.7 Perfect Forecasting Excess Inventory With Varying Length of Decommissioning Period (Case #7).

C. PERFECT FORECASTING SUMMARY

In this chapter, seven different sensitivity analyses of the UICP model were conducted. The main result in each case has been that, even with a perfect forecast, the current UICP inventory model produces excess inventory at the end of the

decommissioning period. Table 4.1 provides a summary of the mean excess inventory produced in each perfect forecasting simulation case. The values recorded in the table are the overall averages for each case and were obtained by summing the excess inventory resulting from each simulation in a case and dividing that sum by the number of simulations in each case; namely, (six).

TABLE 4.1 PERFECT FORECASTING SUMMARY

Case	Mean Excess Inventory (units)
#1	1919.2
#2	1184.5
#3	1085.3
#4	2020.0
#5	2191.2
#6	1540.3
#7	1676.2

The amount of the excess varies with certain parameter settings. Especially large amounts of excess inventory are produced when the mean quarterly demand is high, procurement lead time is long, or when the decommissioning period is short. This provides strong evidence that a solution to the problem of excess inventory cannot be found solely through improvements in demand forecasting techniques. In order to make significant progress with the problem of excess inventory, we must also modify the UICP inventory model so that it anticipates the future changes in mean demand.

V. LINEAR Q/R

As is evident from our discussion of perfect forecasting, the reduction of excess inventory can only be partially accomplished by improving demand forecasting techniques at the wholesale level. Further progress can only be made by modifying the inventory model itself in order to anticipate the nonstationary mean demand pattern.

A. A SIMPLE APPROACH

The approach we took in developing a modification to the UICP inventory model was to develop an inventory model that computes a schedule of declining Q and R values in anticipation of the decommissioning period. We have called this modified UICP inventory model "Linear Q/R." The values used at the start of this schedule are the order quantity Q and reorder point R computed by the existing UICP inventory model prior to the start of the decommissioning period. These values of Q and R are reduced linearly to levels that correspond to the demand anticipated at the end of the decommissioning cycle. This approach is simple, is compatible with any min/max type of inventory control system, and particularly with the UICP inventory system. In simulation runs, the Linear Q/R method was found to make significant

reductions in the amount of excess material on hand at the end of the decommissioning period. The results of these runs are presented later in this chapter.

B. ASSUMPTIONS

There are several simplifying assumptions made in the development of the Linear Q/R method. First, it is assumed that the majority of the demand experienced by the inventory manager is the result of material failure rather than some logistical problem such as loss or damage in shipment. In addition, it is assumed the weapon systems in which the parts are installed contribute equally to the total demand rate. Therefore, the retirement of one such system from the population will proportionately reduce the demand rate for the system's component parts. The decline in mean demand over time is assumed to be the result of equipment retirement. The retirement schedule is assumed to be linear; i.e., an equal number of units will be retired each quarter until the end of the decommissioning schedule.

C. COMPUTATIONS

With these assumptions in place, the first step in developing the Linear Q/R schedule is to compute values for Q and R at the end of the decommissioning period. For cases where all the equipment is being phased out, this computation is simple; i.e., $Q = 0$, $R = 0$. However, when material is used

in more than one weapon system, the ending values of Q and R will depend on the future demand. One way of forecasting this future quarterly demand is to estimate the mean total demand rate prior to decommissioning or retirement and then subtract the mean demand associated with the equipment that has been phased out. In the model, this calculation is made by multiplying the forecasted demand of the quarter in which the Linear Q/R schedule is implemented by the fraction of population remaining at the end of the decommissioning cycle. The formula below shows this computation:

$$D_e = D_i \left(\frac{P_b - P_r}{P_b} \right)$$

where: D_e=Ending Forecast
D_i=Initial Demand Forecast at the Linear Q/R implementation quarter
P_b=Population prior to equipment retirement
P_r=Population Retired

Because this simulation will not have a perfect forecast of demand, the MAD of quarterly demand must be computed and used in the computation of Q and R. To this end, the model uses the power rule to estimate that MAD based on the forecast at the end of the decommissioning period [Ref. 15:p. 3-29].[7] The computation is made using the following formula:

[7] The power rule is used by SPCC to estimate MAD for a given demand value. In the model, a and b are set at .5 and .8 respectively.

$$MAD_e = [D_e]^a * b$$

where: MAD_e=Forecasted MAD of demand at end of Decommissioning Period.
D_e=Future Demand Forecast.
a=SPCC defined value of 0.5.
b=SPCC defined value of 0.8.

Using these reduced forecasts of mean quarterly demand and the MAD for quarterly demand, the Q and R values applicable to the end of the decommissioning period are computed based on the existing UICP inventory model.

Using these Q and R estimates, a Linear Q/R schedule is developed by calculating the differences between the beginning and ending Q and R values and reducing them proportionally over the length of the scheduled decommissioning cycle. Quarterly linear reductions of Q and R are calculated as follows:

$$Q_{t+n} = Q_B - (Q_B - Q_E)\,\frac{t+n}{S}$$

where: t=Linear Q/R implementation quarter;
n=number of quarters following the start of Linear Q/R;
t+n=nth quarter of Linear Q/R schedule;
Q_{t+n}=Forecasted Q estimate for the t+nth period of the Linear Q/R schedule;
S=length of decommissioning period;
Q_B=Q for original population; and
Q_E=Q estimate for ending population.

$$R_{t+n} = R_B - (R_B - R_E)\,\frac{t+n}{S}$$

where: t=Linear Q/R implementation quarter;
n=number of quarters following the start of Linear Q/R;
$t+n$=nth quarter of Linear Q/R schedule;
R_{t+n}=Forecasted R estimate for the t+nth period of the Linear Q/R schedule;
S=length of decommissioning period;
R_B=R for original population; and
R_E=R estimate for ending population.

Once this schedule is determined, it is used in place of the normal quarterly UICP computations until the decommissioning period has ended. Because Linear Q/R values are based on the level of demand that is forecasted to exist after the decommissioning is done, they can be used to anticipate the decline in the demand pattern that realistically match the reduced requirements.

In using this Linear Q/R schedule, a critical issue involves the point in time at which it should be implemented. As a starting point, the linear reduction of Q and R was implemented one procurement lead time (L) prior to the starting quarter of the decommissioning cycle (T). This makes intuitive sense with respect to the reorder quantity because orders placed at time (T-L) are received at time (T). If orders placed at time (T-L) are received at some point (T) during the decommissioning cycle, the order size should be smaller so that it matches the reduced demand in period (T). In a similar way a reduced reorder point is also computed. As discussed earlier in this thesis paper, R is equal to lead time demand plus some amount of safety stock. In a situation involving declining mean demand, mean lead time demand can be

expected to decrease in the future, as the mean demand decreases. Therefore, R must be decreased to reflect the new and lower lead time demand levels.

D. LINEAR Q/R DATA SIMULATIONS

1. PROGRAM MODIFICATIONS

In order to study the effect of the Linear Q/R model on the UICP model's performance when Linear Q/R is implemented one procurement lead time prior to the start of a decommissioning cycle (T-L), we modified the inventory simulation described in Chapter IV in several ways. First, instead of perfect forecasts, we introduced the basic forecasting method presently used by the Navy Ships Parts Control Center (SPCC). Normal forecasting errors experienced at SPCC were thus introduced into the experiments. The current forecasting method at SPCC uses simple exponential smoothing for most forecasts. In addition, the demand pattern is tested for trend by using the recently implemented Kendall trend test. This test measures the amount of trend present in the demand data by examining how often recent demand observations exceed or are less than older demand observations. If the Kendall trend test finds enough evidence of a trend, SPCC switches the demand forecast from exponential smoothing to a 4-quarter moving average. [Ref. 16] In doing so they reduce historical forecast lags.

Second, we added a LOTUS macro that computes a Linear Q/R schedule and inserts it into the inventory position calculator at a point in time specified by the user of the software. Finally, we added the capability to record average customer wait time (ACWT) prior to and after Linear Q/R implementation. This enables us to study the effects of the Linear Q/R model on customer service levels. Documentation for these parts of the program are contained in Appendix C.

2. INITIAL CONDITIONS AND PARAMETERS

As mentioned above, Linear Q/R implementation was set at one procurement lead time prior to the start of the decommissioning schedule for the simulations. For consistency between the next sets of simulations and the results of the preceding Chapter, the following system parameters were set to the same values used in the perfect forecasting experiment and were held constant from quarter to quarter:

- The mean absolute deviation (MAD) of LT time is 0.01 quarters.
- The annual holding cost rate per year is 23% of the unit cost.
- The unit cost is $500.
- The administrative cost of placing an order with the manufacturer is $740 per order.
- The shortage cost is $1000 per unit.
- The minimum risk constraint value is 0.1.
- The maximum risk constraint value is 0.35.
- The item manager has designated no policy receivers.
- The essentiality value for the item is 1.
- The low limit for the reorder point is 1.
- Average requisition size is 4.2 units.
- Discount quantity is 0.
- Shelf Life is 9999 yrs.
- Probability break point is 0.

In addition, the behavior of lead time demand is assumed be described by a Normal distribution.

The initial inventory position in period zero is set the same way as it was in the perfect forecasting simulations; i.e., equal to the estimated inventory on hand (OH_0) plus the estimated quantity on order (OO_0). Inventory OH_0 was set equal to one half of the initial Q plus safety stock (SS_0) as generated by the UICP model:

$$OH_0 = \left(\frac{Q_0}{2}\right) + SS_0 \ .$$

Outstanding orders at the start of the simulation are set equal to the product of the integer value of mean lead time demand divided by the reorder quantity (Q_0); that is,

$$OO_0 = \left\lfloor \frac{LTD}{Q_0} \right\rfloor (Q_0) \ .$$

3. LINEAR Q/R SIMULATIONS

Inventory simulations were run in order to compare the performance as measured by the resulting mean excess inventory and ACWT of the UICP model with the modified version incorporating Linear Q/R during declining demand periods. The simulations examined how these performance measures varied with changes in:

1. mean quarterly demand;
2. variability of quarterly demand;
3. length of procurement lead time; and
4. length of the decommissioning schedule.

In order to limit the number of simulation cases needed to thoroughly evaluate the effects, seven specific sets of settings for these parameters were used during the simulations to produce a representative range of possible outcomes. Test results for each simulation series are contained in Appendix C.

a. Linear Q/R Simulation Case #1

The first simulation case examined the effect of increasing mean quarterly demand levels on the performance of the UICP inventory model and Linear Q/R. In this series of runs, mean quarterly demand was increased from 10 units per quarter to 510 units per quarter in intervals of 100 units per quarter. The standard deviation of quarterly demand was set at 30% of the mean quarterly demand value, procurement lead time was set at seven quarters, and the decommissioning period was set at four quarters.

Figure 5.1 displays the comparison of mean excess inventory resulting from the UICP model and the UICP model with Linear Q/R. Excess inventory is reduced to very low levels with Linear Q/R. However, there is a large increase in average customer weight time occurs with the Linear Q/R model (Figure 5.2). This issue of increased customer wait time (as

measured by ACWT), and suggestions to improve it are discussed later in this chapter.[8]

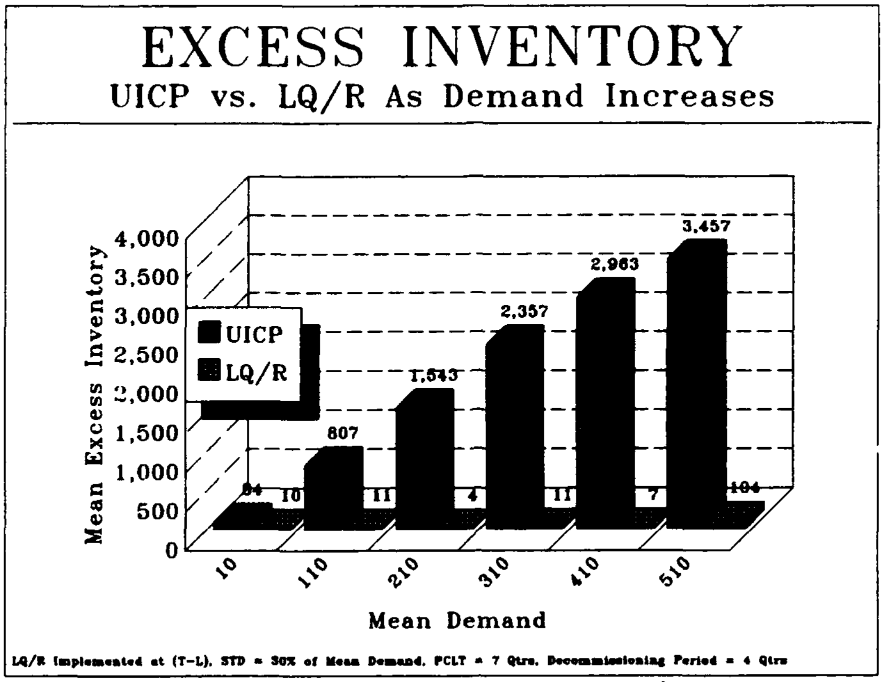

Figure 5.1 Excess Inventory With Increasing Mean Quarterly Demand and A Decommissioning Period of Four Quarters.

b. Linear Q/R Simulation Case #2

The next simulation case was similar to Case #1 with the exception of the length of the decommissioning schedule. In this case, the decommissioning schedule was 12 quarters long. Mean quarterly demand was again increased quarterly from 10 to 510 in increments of 100 units. The

[8]Figure 5.2 shows a peak in ACWT at a mean quarterly demand setting of 310 units. This result is common in many of the simulation cases for both the UICP model and the UICP model with Linear Q/R. More extensive exploration of this phenomenon is needed for both models under various parameter settings to determine the cause.

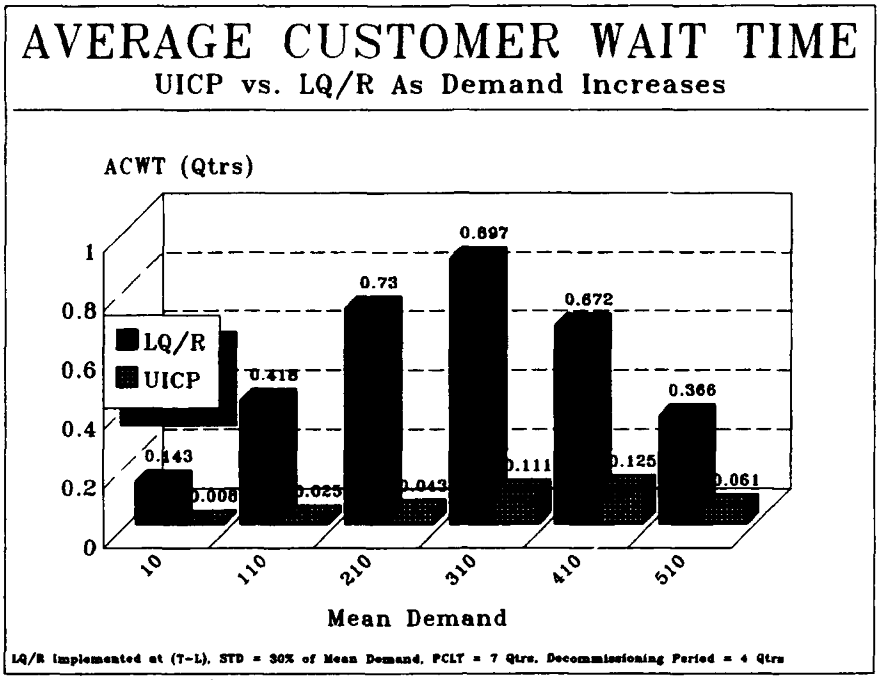

Figure 5.2 ACWT With Increasing Mean Quarterly Demand and A Decommissioning Period of Four Quarters.

standard deviation for quarterly demand was set at 30% of the mean quarterly demand value, and procurement lead time was seven quarters. Figure 5.3 displays the comparison of excess inventory resulting from the UICP model and the UICP model with Linear Q/R. A decrease in excess inventory can be seen by comparing these results to those displayed in Figure 5.1. As was explained in the previous chapter, the longer decommissioning schedule uses up a greater portion of the inventory position present at the beginning of the decommissioning period and therefore produces lower levels of excess. Figure 5.4 shows the increase in ACWT that results from UICP with Linear Q/R.

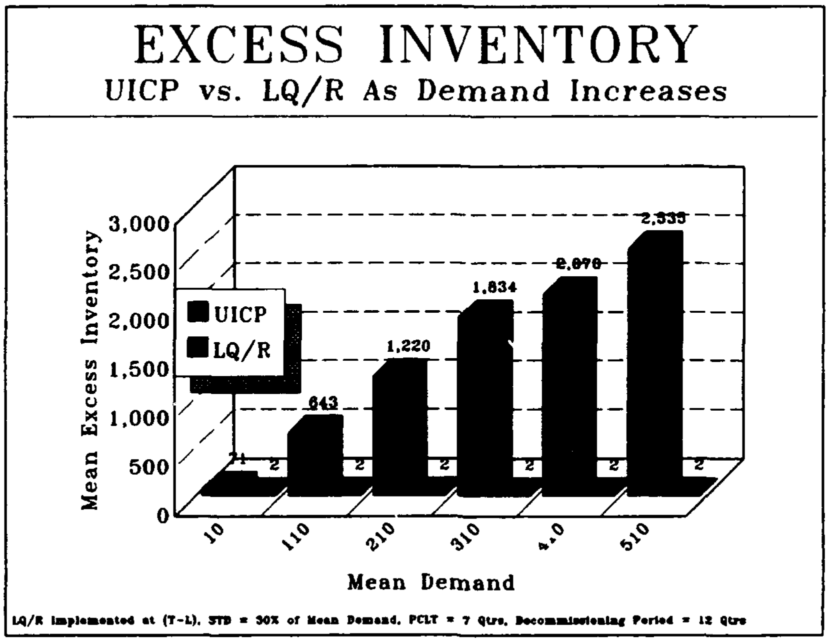

Figure 5.3 Excess Inventory With Increasing Mean Quarterly Demand and A Decommissioning Period of 12 Quarters.

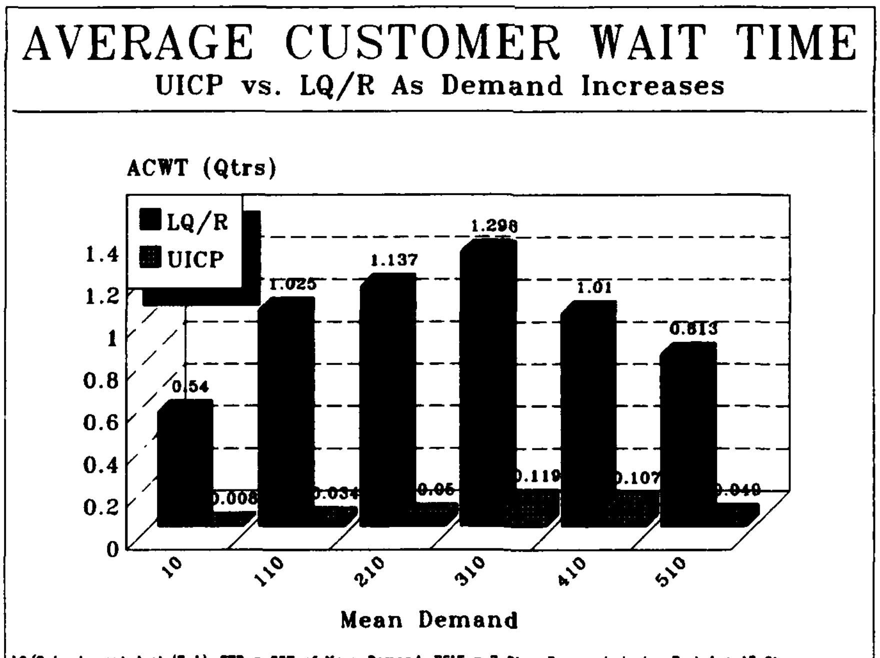

Figure 5.4 ACWT With Increasing Mean Quarterly Demand and A Decommissioning Period of 12 Quarters.

c. Linear Q/R Simulation Cases #3 and #4

The third and fourth simulation cases were designed to test the effect of quarterly demand variability on performance of the UICP with Linear Q/R. To make this analysis, the standard deviation of demand was set at 10% of mean quarterly demand in case #3 and increased to 50% during case #4. The other parameters for both experiments were set as follows:

- mean quarterly demand was varied from 10 to 510 in six increments;
- procurement lead time was set to 7 quarters; and
- decommissioning period length was set to 8 quarters.

Figures 5.5 and 5.6 display a comparison of excess inventory resulting from the UICP model and the UICP model with linear Q/R implemented. By comparing these two figures, the decrease in excess inventory can be easily seen. The increase in ACWT resulting from the implementation of Linear Q/R for each experiment is shown in Figures 5.7 and 5.8.

d. Linear Q/R Simulation Case #5

Simulation Case #5 explored the impact of increasing procurement lead time on Linear Q/R. For this simulation, the length of the procurement lead time was increased from two to 12 quarters in increments of two quarters. Mean quarterly demand was set at 310 units per

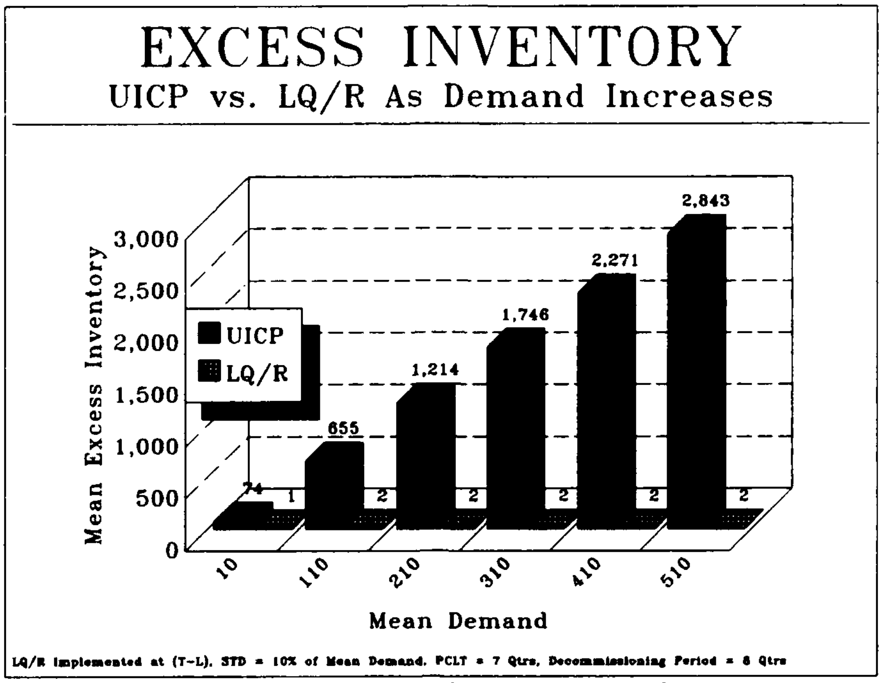

Figure 5.5 Excess Inventory With Increasing Mean Quarterly Demand and Low Variability of Demand.

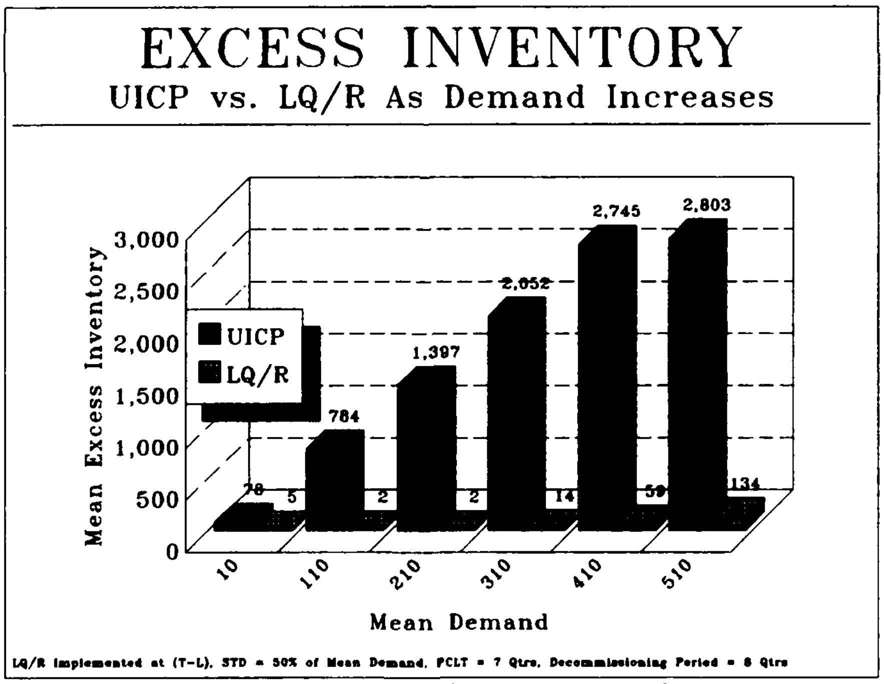

Figure 5.6 Excess Inventory With Increasing Mean Quarterly Demand and High Variability of Demand.

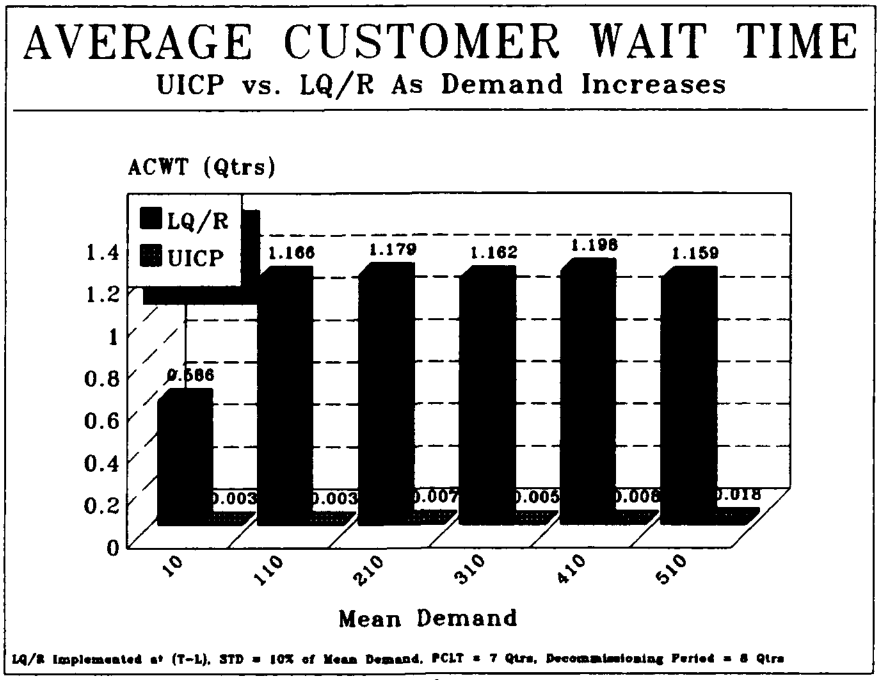

Figure 5.7 ACWT With Increasing Mean Quarterly Demand and Low Variability of Demand.

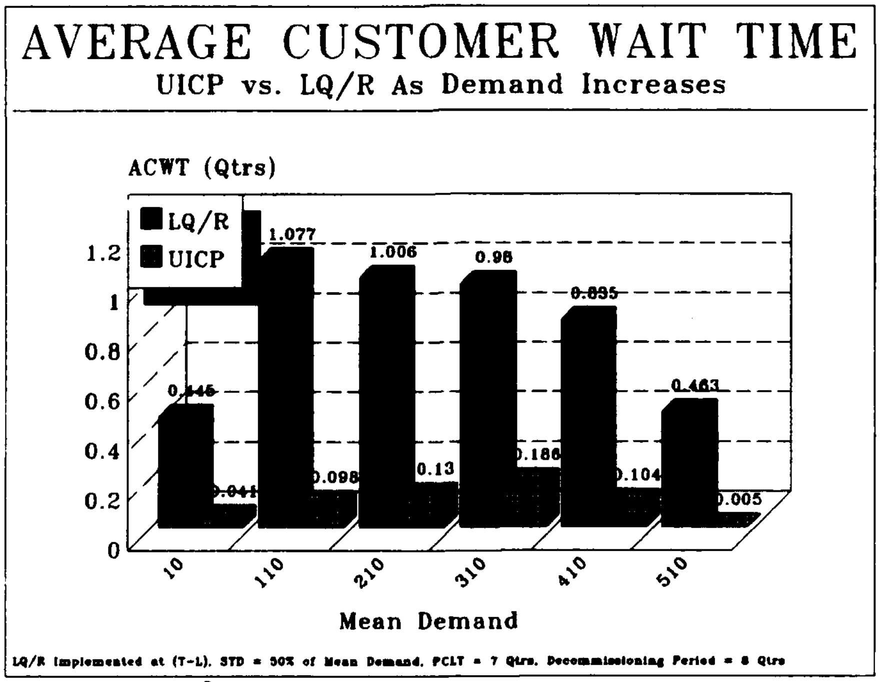

Figure 5.8 ACWT With Increasing Mean Quarterly Demand and High Variability of Demand.

quarter and the standard deviation of demand was set at 30% of the mean quarterly demand value. For this series, decommissioning length was four quarters long. Figure 5.9 displays the comparison of excess inventory generated by the UICP model and the UICP model with Linear Q/R. The ACWT resulting from this case is displayed in Figure 5.10.

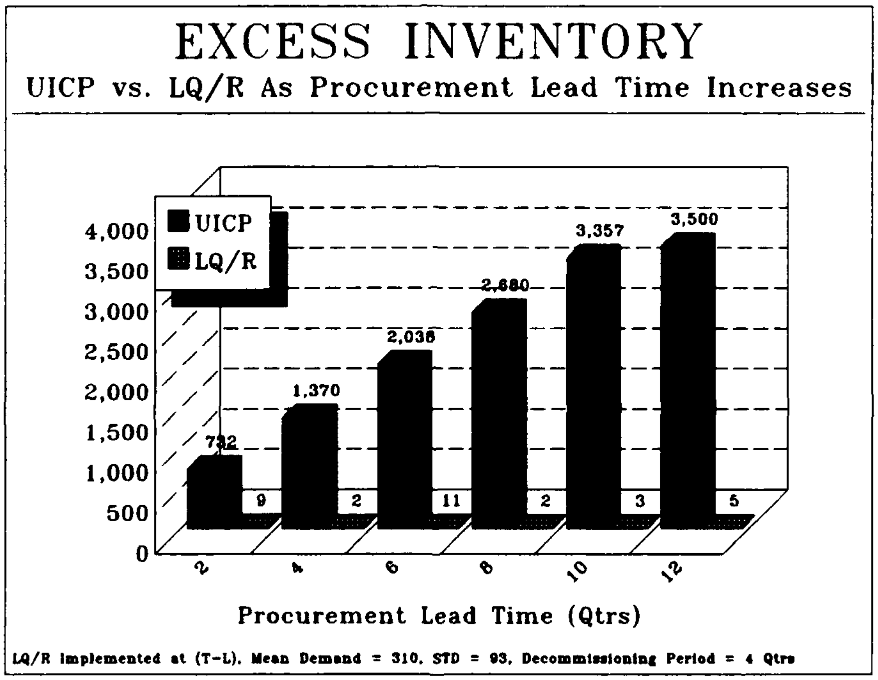

Figure 5.9 Excess Inventory With Increasing PCLT and Decommissioning Period of Four Quarters.

e. Linear Q/R Simulation Case #6

This simulation case is similar to Case #5 except that the decommissioning schedule was increased to 12 quarters. Procurement lead time was again increased from two to 12 quarters in two quarter increments. Mean quarterly demand was set at 310 units per quarter and the standard

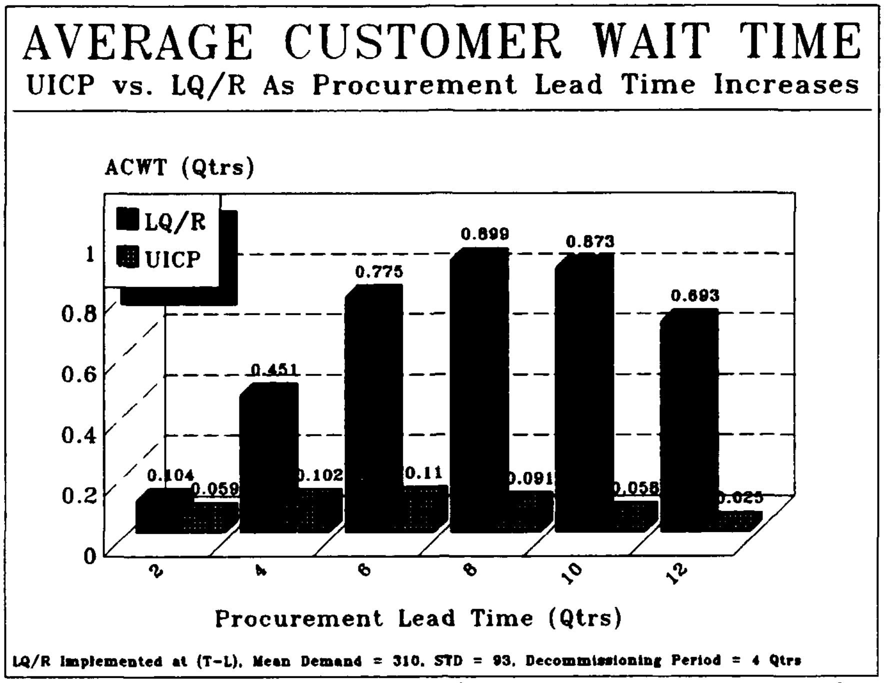

Figure 5.10 ACWT With Increasing PCLT and Decommissioning Period of Four Quarters.

deviation for quarterly demand was 93 units per quarter. Figure 5.11 displays the comparison of the excess inventory resulting from the UICP model and the UICP model with Linear Q/R. The increase in ACWT that occurs with UICP with Linear Q/R is shown in Figure 5.12.

f. Linear Q/R Simulation Case #7

In the final set of simulations, the effect of increasing the length of the decommissioning schedule was examined. In this case, the length of the decommissioning schedule was increased from four quarters to 14 quarters in increments of two quarters. Mean quarterly demand was set at 310 units per quarter, the standard deviation for quarterly

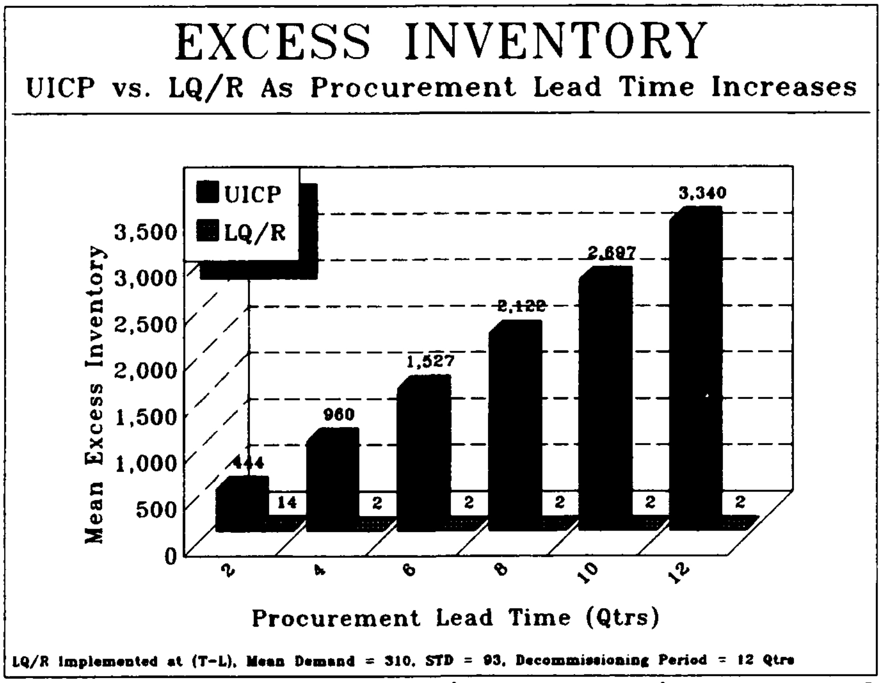

Figure 5.11 Excess Inventory With Increasing PCLT and a Long Decommissioning Period.

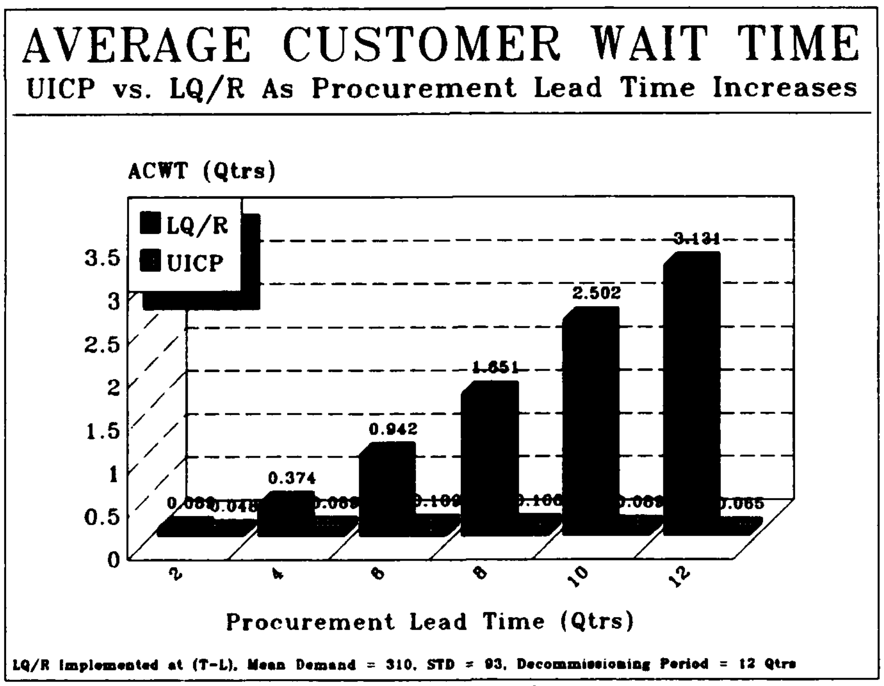

Figure 5.12 ACWT With Increasing PCLT and a Long Decommissioning Period.

demand was set at 93 units, and the length of procurement lead time was set at seven quarters. A comparison of the resulting excess inventories is shown in Figure 5.13. The increase in ACWT resulting from the UICP model with Linear Q/R implemented is shown in Figure 5.14.

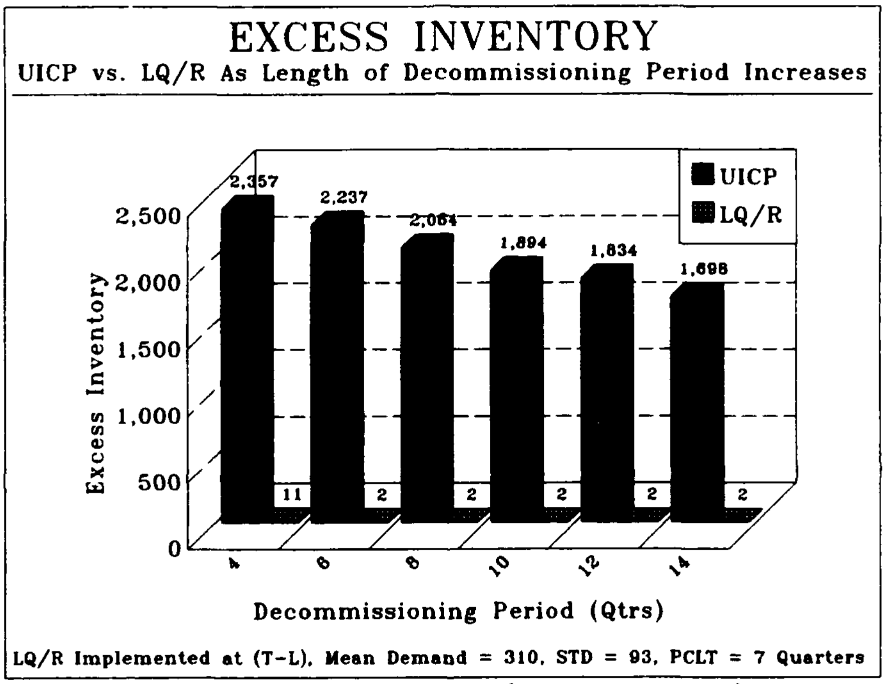

Figure 5.13 Excess Inventory With Increasing Length of Decommissioning Period.

4. ANALYSIS OF LINEAR Q/R INVENTORY SIMULATION CASES

The data presented in this chapter thus far clearly demonstrates that the Linear Q/R model can effectively reduce excess inventory. An overall decrease in mean excess inventory of 99.2% was experienced in the simulations as a

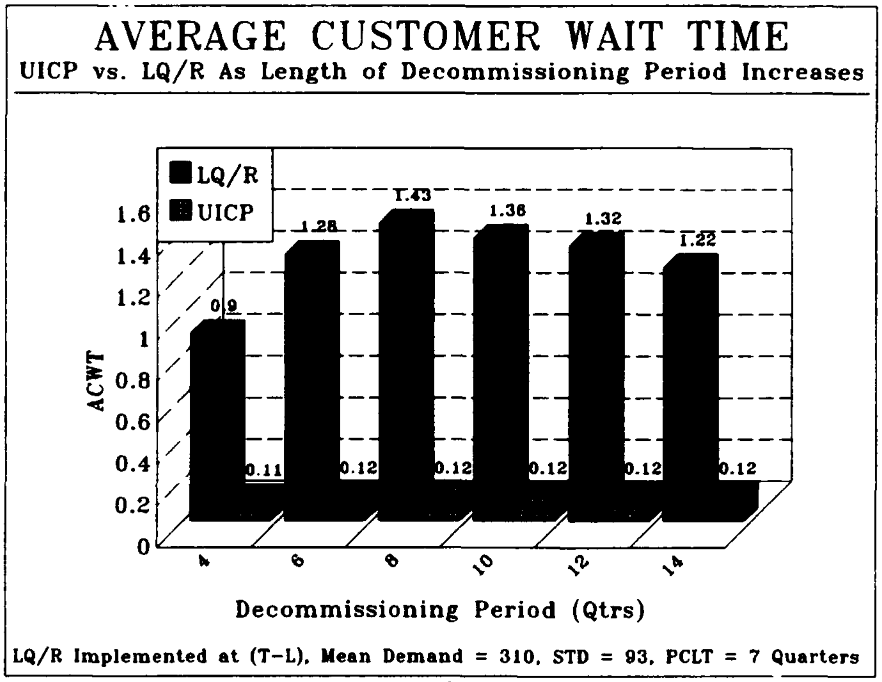

Figure 5.14 ACWT With Increasing Length of Decommissioning Period.

result of the Linear Q/R model. While Linear Q/R is an effective tool for reducing excess inventory during declining demand periods, it results in a serious decrease in customer service levels as measured by average customer wait time (ACWT). This drop in customer service begins at the point in time when the Linear Q/R model is implemented.

Table 5.1 is a summary of results from these first seven cases. As in the previous chapter, the values shown in the table 5.1 are an overall average for each case obtained by summing the excess inventory and ACWT resulting from each simulation in a case and dividing by the number of simulations in the case (6).

TABLE 5.1 LINEAR Q/R SUMMARY

Case	Mean Excess Inventory (units)		Average Customer Wait Time (quarters)	
	UICP	LQ/R	UICP	LQ/R
#1	1601.6	20.91	.062	.467
#2	1196.1	1.33	.052	.832
#3	1257.4	1.33	.006	.921
#4	1408.4	30.75	.080	.687
#5	2029.1	4.32	.064	.542
#6	1584.3	3.20	.072	1.24
#7	1726.3	2.76	.101	1.07

The next section of this chapter examines the problem of the large ACWT values observed in this section and considers modifications to the Linear Q/R version of the UICP model which should help reduce the ACWTs.

E. LINEAR Q/R IMPLEMENTATION ANALYSIS

As was observed in the previous section, the linear Q/R model made significant reductions in inapplicable inventory in every simulation case. However, these reductions are accompanied by a substantial increase in ACWT. A review of the test data indicates that this increase began at the point in time when Linear Q/R is implemented. When this implementation occurs one procurement lead time prior to the start of the decommissioning period, inventory levels immediately begin decreasing rapidly and quickly became insufficient to meet lead time demand. As a result, the

demand occurring during the first several periods of the decommissioning schedule is mostly backordered.

In an attempt to reduce this increase in ACWT when using the Linear Q/R model, we experimented with delaying the implementation point from one to 5 quarters. In each experiment we recorded the ACWT and excess inventory resulting from the simulations. These experiments were performed using three scenarios.

1. IMPLEMENTATION POINT SIMULATION CASE #1

For the first simulation case, mean quarterly demand was set at 310 units per quarter, the standard deviation of quarterly demand was 155 units, procurement lead time was seven quarters, and the decommissioning period was four quarters. Simulation runs were then made using six different implementation points for the Linear Q/R Model beginning with time T-L (where T is the first quarter of the decommissioning cycle and L is lead time.) and then delaying implementation from one to five quarters (T-L+1 through T-L+5) for the subsequent runs.

Figure 5.15 shows the resulting mean excess inventories from each implementation time delay. It should be noted that even though excess inventory gradually increased as the implementation of the Linear Q/R model was delayed, there was still a significant reduction in excess inventory from using Linear Q/R as compared to the UICP model without it.

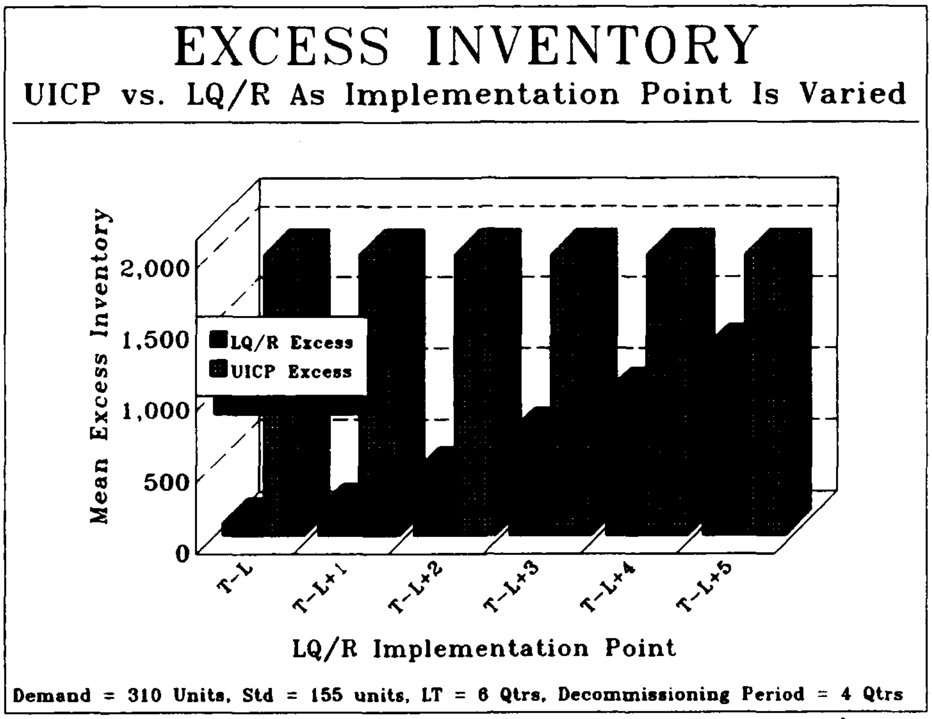

Figure 5.15 Excess Inventory for Implementation Point Simulation Case #1.

The corresponding decrease in ACWT is shown in Figure 5.16. It should be noted that the ACWT obtained from the Linear Q/R model implemented at time T-L+2 is equal tc the ACWT obtained using the UICP inventory model. ACWT remains at this level for the remainder of the implementation point values. This implies that the number of backorder demands and their delays in being filled for Linear Q/R and UICP is the same for implementation times T-L+2 through T-L+5.

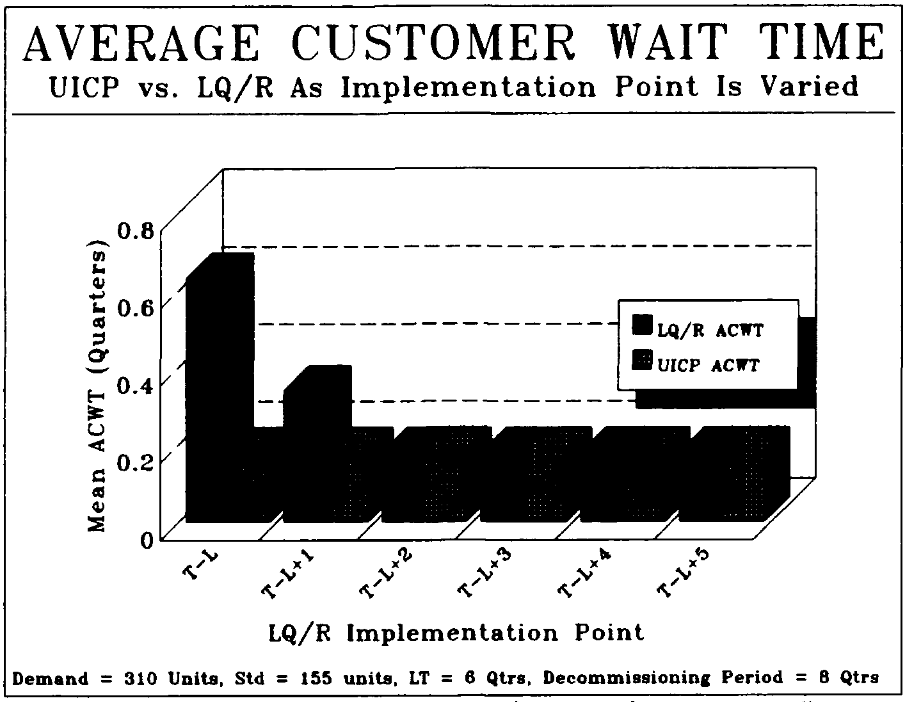

Figure 5.16 ACWT for Implementation Point Case #1.

2. IMPLEMENTATION POINT SIMULATION CASE #2

For the second case, the decommissioning schedule was increased to 12 quarters. The rest of the analysis was conducted in the same way as the implementation point Case #1. Again, six different implementation points were used for the Linear Q/R Model beginning with time T-L and then delaying implementation from one to five quarters (T-L+1 through T-L+5) for the subsequent runs. Mean quarterly demand was again set at 310 units per quarter, the standard deviation of quarterly demand was 93 units, and procurement lead time was set at 7 quarters. As shown in Figure 5.17, excess inventory under Linear Q/R lid not increase until the point where implementation was delayed by 3 periods; i.e., time T-L+3. In

this case, all delay-points for the Linear Q/R version of the UICP model significantly reduced excess inventory over that of the UICP model.

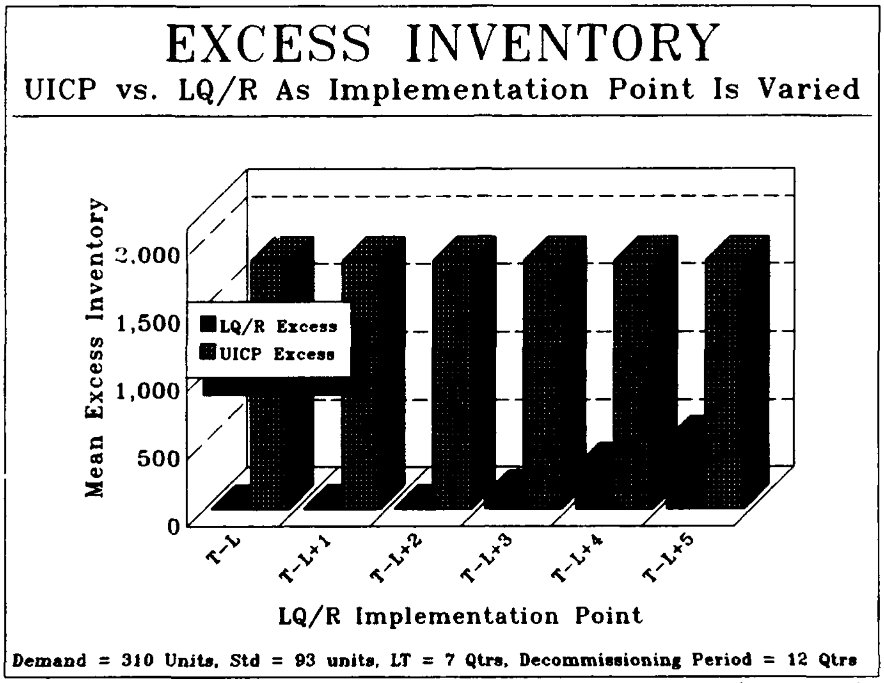

Figure 5.17 Excess Inventory for Implementation Point Case #2.

ACWT decreased dramatically with each quarter of delay of implementation of Linear Q/R. In this case, ACWT for Linear Q/R drops to the UICP level when implementation occurs at time T-L+5 (Figure 5.19).

It is interesting to compare the excess inventory levels produced by UICP as decommissioning lengths are increased from 4 and 12 quarters. A comparison of implementation simulation #1 and #2 make it is clear that the length of the decommissioning period does not significantly

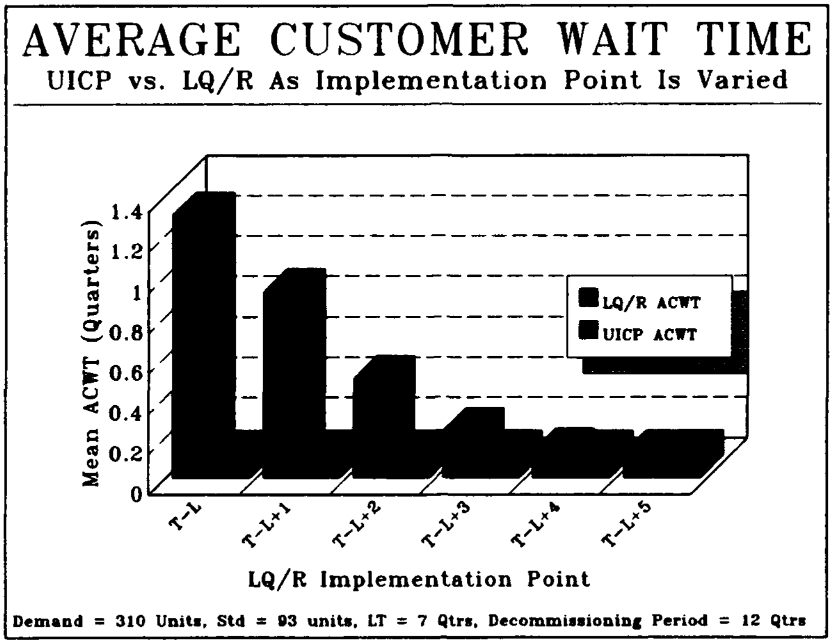

Figure 5.18 ACWT Implementation Point Case #2.

impact the performance of UICP or UICP with Linear Q/R with regard to excess inventory.

3. IMPLEMENTATION POINT CASE SIMULATION #3

For the final case, we examined the effect of low demand variability by setting the standard deviation of demand equal to 31 units or 10% of mean demand. Mean quarterly demand was again set at 310 units per quarter, procurement lead time was set at 7 quarters. The length of the decommissioning period was 8 quarters. As in the previous cases, excess inventory was dramatically reduced by using Linear Q/R. The excess generated by Linear Q/R did not increase until implementation was delayed until time T-L+3,

and the increases that occurred were relatively small (see Figure 5.19).

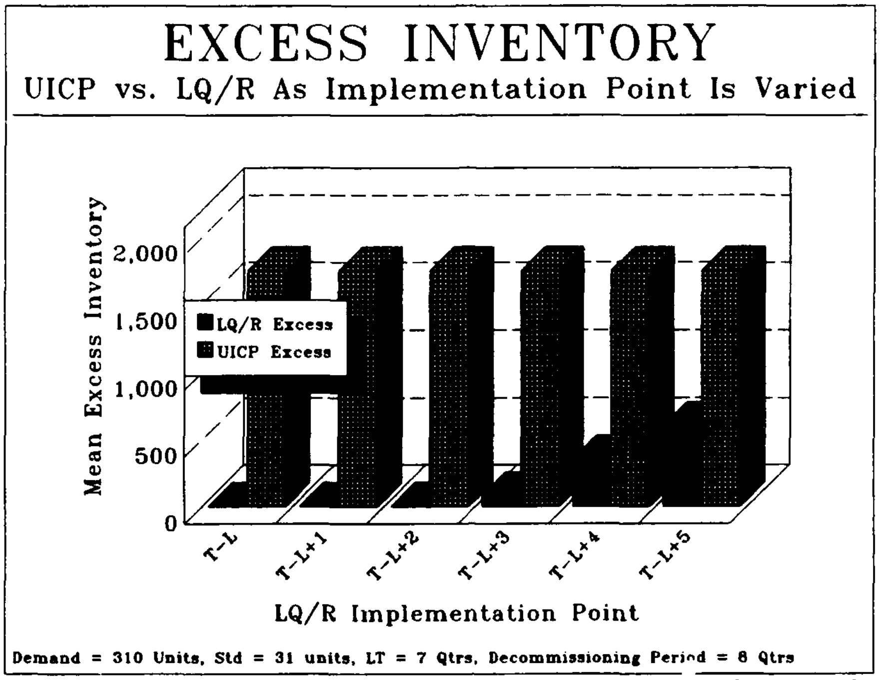

Figure 5.19 Excess Inventory for Implementation Point Case #3.

The results for ACWT for this simulation are shown in Figure 5.20. With the lower demand variability and a medium length decommissioning schedule, ACWT can be reduced to the levels that occur in the UICP inventory model by implementing Linear Q/R at time T-L+3. This is two quarters earlier than in simulation case #1.

4. IMPLEMENTATION ANALYSIS SUMMARY

In the three implementation point cases examined in this section we have seen that the point in time at which the Linear Q/R model is implemented can greatly improve ACWT. However, as expected the improvement in ACWT is slightly

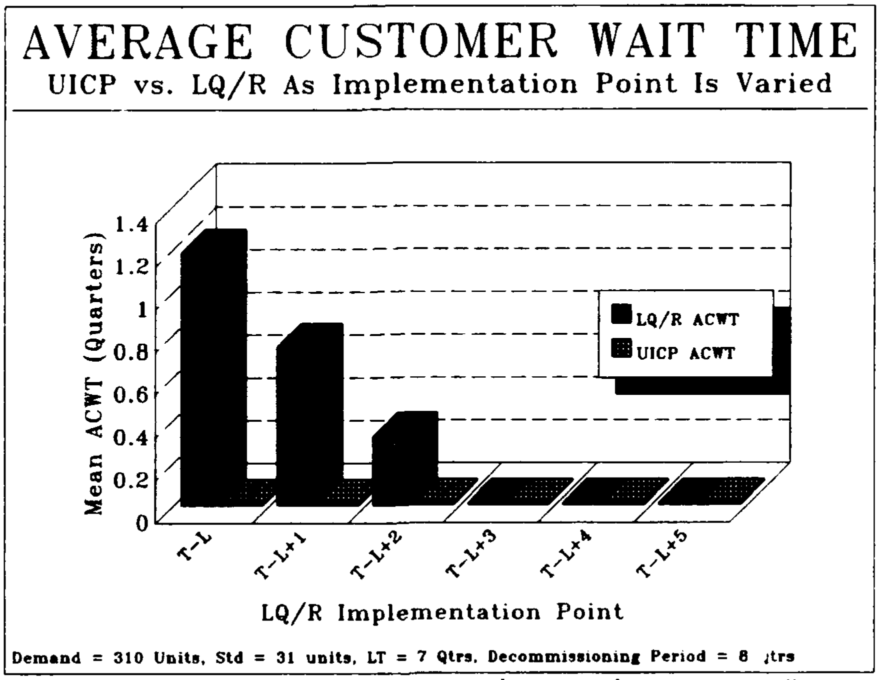

Figure 5.20 ACWT for Implementation Point Case #3.

offset by an increase in the amount of excess inventory. Summaries of the resulting mean amounts of excess inventory and ACWT are shown in Table 5.2 and Table 5.3, respectively. The values recorded in the tables below are an overall average for each series obtained by summing the excess inventory and ACWT resulting from each simulation in a series and dividing by the number of simulations in the series (6).

TABLE 5.2 IMPLEMENTATION POINT STUDY SUMMARY RESULTS

Mean Excess Inventory (units)							
Case	**UICP**	**Linear Q/R at time:**					
		T-L	**T-L+1**	**T-L+2**	**T-L+3**	**T-L+4**	**T-L+5**
#1	1968	87.20	185.00	438.00	712.00	997	1297
#2	1834	1.72	1.79	1.80	108.00	310	507
#3	1746	1.50	1.59	1.53	77.80	348	598

TABLE 5.3 IMPLEMENTATION POINT STUDY SUMMARY RESULTS

ACWT (quarters)							
Case	UICP	Linear Q/R at time:					
		T-L	T-L+1	T-L+2	T-L+3	T-L+4	T-L+5
#1	.18	.65	.34	.18	.18	.18	.18
#2	.12	1.30	.92	.49	.23	.13	.13
#3	.01	1.18	.74	.32	.010	.01	.01

VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. SUMMARY

The Navy's inventory management system has historically been ineffective at preventing the accumulation of inapplicable inventories when equipment is retired from service. In this thesis, we discussed the two reasons why the existing UICP inventory model cannot effectively deal with these retirements. First, its reactive forecasting method lags behind the actual demand and thus produces Q and R values in excess of what are actually needed. Our simulations of UICP performance under perfect forecasting in Chapter IV clearly demonstrate the limitations that any improved forecasting methods have with regard to reducing inapplicable inventory.

The second problem with the existing UICP inventory model is the assumption that mean quarterly demand is constant. When a decline in mean quarterly demand occurs after the quarterly computation of Q and R, it renders these values obsolete but they are used anyway. To eliminate excess inventory levels resulting as a consequence of this phenomenon, the Linear Q/R model proposed in Chapter V develops an advance schedule of Q and R values that decrease linearly to the appropriate levels corresponding to the demand

patterns remaining at the end of the decommissioning period after a weapon system has been phased out of service.

Model testing in Chapter V showed this method to be very effective in eliminating excess inventory. However, the improvement comes at the expense of customer service. Implementing Linear Q/R one procurement lead time prior to the start of the decommissioning period virtually eliminated excess inventory in all of the cases that were studied, but resulted in significant increases in average customer wait time (ACWT). It was shown in the last section of Chapter V that by delaying the point in time at which Linear Q/R is implemented, customer service levels could be improved while retaining most of the reductions in excess inventory.

B. CONCLUSIONS

As is true with most logistical problems, inventory managers faced with declining mean quarterly demand must make decisions that attempt to balance different costs. In this case, the item manager must attempt to balance the estimated costs of increased customer wait time against the holding and disposal costs involved with inapplicable inventory. While the Linear Q/R model may not provide the final answer to the problem of inapplicable inventory, it can be used as a decision tool. It provides an empirical approach toward developing lot sizes and reorder points during decommissioning

cycles that can be used to supplement the "gut instinct" presently used by Navy wholesale item managers.

C. RECOMMENDATIONS

1. APPLICATION OF THE LINEAR Q/R MODEL

The Linear Q/R inventory model could be used by a wholesale level inventory manager to develop a schedule of declining Q and R values to be used at his or her discretion. Depending on the importance of customer service and priority of the item being considered, the item manager could implement the Linear Q/R schedule at a point in time that produces the desired tradeoffs between customer wait time and the cost of excess material. In this way the reduction in excess inventory during periods of declining mean demand could be balanced against the providing for maintenance of adequate customer service (acceptable ACWT) during this period.

In addition, it may be possible to develop computer software that performs an iterative computation of Linear Q/R. The computation could be constrained by ACWT and halted when a predetermined estimated ACWT value was reached. While this method may produce low levels of excess inventory with minimal increases in ACWT, the amount of computation time such an approach would require has not yet been investigated.

2. RECOMMENDATIONS FOR FURTHER TESTING

The Linear Q/R method developed in this thesis is in some ways limited by the program language and computer

hardware used for the simulations. The Linear Q/R LOTUS simulations required some manual intervention and ran somewhat slowly. (One simulation took approximately five minutes on an IBM compatible 386 DX, 40 MH personal computer.) In addition, the effects of procurement lead time random variability could not be explored due to program limitations. Through the use of another simulation language, it may also be possible to more thoroughly explore the problem over a wider range of parameters. In addition, from a large volume of simulation results, it may be possible to develop a table of Linear Q/R implementation points that are statistically shown to the be most efficient, in terms of the best combinations of excess inventory and ACWT, given certain parameter settings.

In addition, as noted from Linear Q/R Simulation Case #1 presented in Chapter V of this thesis, additional research into the cause of the peaks in ACWT at the median settings of mean quarterly demand is needed. This research is necessary for both the UICP model and the UICP model with Linear Q/R.

3. FUTURE RESEARCH

In addition to the Linear Q/R inventory model described in this thesis, many deterministic inventory models exist that, with appropriate modifications, may have application to stochastic inventory management during brief periods of declining demand. For example, it may be possible

to modify some of models described by Tersine [Ref. 23:p. 161-182] so that they are effective in dealing with periods of declining mean quarterly demand. These models include:

- Lot For Lot Ordering.
- Periodic Order Quantity.
- Wagner-Whitin Algorithm.
- Part Period Algorithm.
- Incremental Part-Period Algorithm.
- Silver-Meal Algorithm.

APPENDIX A

PERFECT FORECASTER LOTUS MODULE DOCUMENTATION

The Perfect Forecaster inventory model was written in Lotus for Windows, Version 1.1. It can be run on Lotus for DOS version 2.4 or later although the windows version is recommended. This documentation explains the computations made during model simulation. Cell formulas are presented in two ways. First, in Lotus format, but where practical, with verbal descriptions in place of actual cell locations for ease of understanding. Second, the actual cell code is included for model verification and testing. (Note: When formulas are repeated over a range of cells, only the code for the first field of the range is presented in the documentation.)
The model is organized into seven functional areas. Each major area is listed below and underlined. The range in which it appears in the spread sheet is noted in parentheses following the section name.

<u>Section #1 DEMAND FORECASTER: (M1..V42)</u>
The demand forecaster sets forecasts equal to actual demand in order to simulate perfect forecasts.

Rand: (N3..N43) This number is generated by the Normal Random Number generator contained in the model.

Demand: (O3..O43) Demand is the integer value of the random number generated. To adjust the demand to represent decreasing usage as the decommissioning cycle is implemented it is multiplied by the fraction of remaining population. The Lotus formula used is @ROUND(Random number * (beginning population- number decommissioned)/original population,- 0)

Forecast: (P3..P43) Demand Forecast is set equal to actual demand. **Formula**: Forecast (t) = Actual Demand (Y)

MAD: (S84) MAD is set at zero.

Sked: (R3..R43) This column defines the decommissioning schedule to be used in the test. Enter the number of units to be decommissioned in the period.

Population: (V2) Population column indicates the remaining population. This is automatically calculated by subtracting the scheduled decommissioning population

indicated in the previous period. **Formula:** +Population(t-1)-Scheduled Decommission (t)

Original Population: (V3) Used to define original equipment population for the simulation.

Lead Time: (V10) Sets lead time in quarters. This value is used to set UICP Lead time parameter.

Decom Start/End Period: (V13..V14) Indicate when decommissioning schedule begins and ends. These fields are used to calculate total Decline Period.

Total Decline Prd: (V14) Computed as stated above.

Section #2 INVENTORY POSITION CALCULATOR: (A22..K65)
The inventory position calculator automatically calculates the inventory position throughout the life cycle of a repair part. It is designed to cover 40 quarters or ten total years of usage data.

Y: (B25..B65) Y is actual demand. The calculator tests the value of the demand in the forecaster and if it is greater then zero, copies the value down. If the demand is less then zero, a zero is recorded as demand. Formula: @if(demand>0,demand,0)

IP(prd 0): (E25) Inventory position in period zero is the sum of on hand plus on order.

OH(prd 0): (F25) Value is computed by the "Period 0 OH/OO Macro." This macro places mean demand and STD/1.25 into the UICP simulator and computes and Q and R. The OH value is then computed to be Q/2 + safety stock (Q and safety stock are taken directly from UICP simulator).

OO(prd 0) (G25): Value is computed by the "Period 0 OH/OO Macro." Value is equal to the rounded value of Mean Lead time demand/EOQ multiplied by EOQ.

IP(prd 1): (E26) Value is equal to inventory position (t-1), minus actual demand of period (t), plus on order quantity (t). Formula: IP(t-1)-Y(t)+OO(t).

OH(prd 1): (F26) Because this value can never be a negative number, this column tests the value in hidden column L25..L65. If the number is greater then zero, the value is returned. If the number is less then or equal to zero, then zero is returned. Formula: @if(OH>0,OH,0)

Hidden OH: (L25..L65) As stated above, L25 through L65 is a hidden field that calculates the on hand position. This value is calculated by subtracting demand(t) from on hand(t-1) and adding dues(t).

OO: (H26..H65) The "on order" column compares IP of the current quarter [IP(t-1)-demand(t)] to the reorder point. If IP is less then R, the program calculates the integer value of ((R(t) - IP(t-1)+Y)/Q(t)+1) (call it N) and orders N*(Q) units. Note: While orders are placed at the beginning of the quarter, IP is calculated and compared to R prior to placing the order. **Formula:** @IF(IP(t-1) - D(t)<R,(@INT((R(t)-IP(t-1)+Y(t))/Q(t)+1)*Q(t),0)

DUE: (H26..H65) The dues column is used to receive orders placed in the OO column. This column sets the procurement lead time. The value shown in this column is the outstanding order received L periods later. **Formula:** + OO(t-L)

BO: (I25..I65) Backorders are calculated by testing on hand position. If the on hand quantity is negative, the absolute value of the on hand quantity is returned in this cell. If the on hand position is greater then or equal to zero, a this column is filled by a zero.

<u>Section #3 Data Summary: (AS1..AU15)</u>
The summary section compiles simulation data to be saved for future analysis.

UICP Simulator: (P82..AH134)
This simulator approximates the wholesale inventory model used by SPCC to control inventories of consumable items. It doesn't exactly reproduce the computations that would be done by UICP, but it does represent the most important features of the UICP model. This code was obtained from Moore [Ref. 21].

Input Data: Data input fields include:

- Quarterly Demand Forecast
- Forecasted MAD for Demand
- PCLT Forecast (qtrs)
- Holding Cost Rate (%/year)
- Unit Cost($/unit)
- Admin. Order Cost($/order)
- Discount Quantity (Ko)
- Quarterly Requisition Forecast
- Shortage Cost Parameter
- Shelf Life in years
- Minimum Risk Value
- Maximum Risk Value

Probability Distribution
Probability Break Point
Number of Policy Receivers
Low Limit for Reorder Point
Essentiality Value

Simulator Calculations: Calculations of R, and Q are based on the formulas presented below. The following abbreviations are used in the documentation:

Documentation Abbreviations: The following abbreviations ar used in the formula documentation presented below:

Administrative Order Costs/order: A
Demand Forecast/quarter: D
Unit Cost/unit: C
Holding Cost Rate/year: I
Discount Quantity: (Ko)
Shortage Cost Parameter: K
Quarterly Requisition Forecast: F
Essentiality Code: E
Lead Time Demand: LTD
Procurement Lead Time: PLCT
Standard Deviation of Lead Time Demand: SD LTD
Mean Absolute Deviation for Demand: MAD(d)
Mean Absolute Deviation for PLCT: MAD(plct)
Shelf Life: SL
UICP final Reorder Quantity: Q
UICP final Reorder Point: R

Q Star: (T105) @SQRT((8*A*D)/(C*I}), **Cell formula:** @SQRT((8*S90*S84)/ (S88*S89))

Q sub 1: (T106) @MIN((12*D), @MAX (1, Q Star, (Ko * D))), **Cell formula:** @MIN ((12*S84),@MAX(1,T105,(S91*S84)))

Risk Star: (T107) (D*I*C)/((D*I*C)+(K*F*E)), **Cell Formula:** (S84*S88*S89) /((S84*S88*S89) +(S93*S92*S101))

Risk Hat: (T108) @MIN(Max Risk, @MAX(Risk Star, Minimum Risk)), **Cell Formula:** @MIN(S96,@MAX(T107,S95))

Mean LTD: (T109) (((D*PLCT), **Cell Formula:** (S84*S86)

SD LTD: (T110)
@SQRT((PLCT*((1.25*MAD(d))^2))+((D*1.25*MAD(plct))^2)),
Cell Formula: @SQRT((S86*((1.25*S85)^2))+((S84*1.25*S87)^2))

R Star: (T111) For normal distribution (Mean LTD+(Final Z Value)*SD LTD)), **Cell Formula:** (T109+(S123*T110))

Q Hat: (T114) @INT(@MAX(1,@MIN(Q sub 1,(4*D*SL-@MAX(0,(R hat-Mean LTD)))))+0.5), Cell Formula:
@INT(@MAX(1,@MIN($T$106,(4*$S$84*$S$94-@MAX(0,($T$115-$T$109))))) +0.5)

R Hat: (T115) @INT(@MAX(Low limit for Reorder Point,@MIN((D*(4*SL+PLCT-Ko)),@MAX (@IF (Probability Distribution="Normal",R Star(normal) ,@IF(Probability Distribution ="Poisson",R Star (poisson), "Error")) ,# policy receivers)))+0.999), **Cell Formula:**
@INT(@MAX($S$100,@MIN(($S$84*(4*$S$94+$S$86-$S$91)), @ MAX (@IF
($S$97="Normal",$T$111,@IF($S$97="Poisson",$T$112,"Error")), $S$99)))+0.999)

Reorder Qty: (V84) R Hat, **Cell Formula**:
@INT(@MAX(1,@MIN($T$106,(4*$S$84*$S$94-@MAX(0,($T$115-$T$109)))))+0.5)

Reorder Point: (V85)
@INT(@MAX($S$100,@MIN(($S$84*(4*$S$94+$S$86-$S$91))
,@MAX(@IF($S$97="Normal",$T$111,$T$112),$S$99)))+0.999)

Administrative Order Costs/year: (V89) (A*D/Q), **Cell Formula**: (S90*S84/V84)

Holding Costs/year: (v90) (Q*I*C/2)+(I*C*(R-LTD)), **Cell Formula:** (V84*S88*S89/2)+(S88*S89* (V85-T109))

Section #4 Model Macros: The following macros are included in the spreadsheet.

Q*/R* MACRO (Ctl O): (A69..C231)
This macro takes the forecasts and MADs from the forecaster and places them in the UICP simulator contained in this spreadsheet. It allows the UICP to calculate Q* and R* and then copies the values back to the Inventory calculator.

Random Number Generator Macro (Ctl D): (AG1..AP57)
Detailed documentation on the random number generator is provided in spreadsheet. A Chi^2 "Goodness of Fit" test was conducted to test the random number generator. These test results are provided in the Linear Q/R program documentation in Appendix B.

Copy Macro (Ctl Z): (AW8..BD13)
This macro copies the data summary information to a separate LOTUS worksheet for each simulation. Note: It is necessary to have a data worksheet loaded in memory to run this macro.

Problem Parameter Macro (Ctl I): (Y9..AE23)

This macro prompts the user to provide simulation parameters. These parameters include:

- Equipment population
- Lead time in Quarters
- Decommissioning Starting Period
- Decommissioning Ending Period
- Desired mean demand for random number generation
- STD of random demand

UICP Parameter Macro (Ctl U): (Y9..AE23)
This macro prompts the user to enter into UICP the following UICP parameters:

- Unit Cost
- Admin Order Costs
- Discount Quantity
- Quarterly Requisition Forecast
- Shortage Cost Parameter
- Shelf Life (in years)
- Minimum Risk Value
- Maximum Risk Value
- Probability Distribution
- Probability Break Point
- Low Limit for Reorder Point

APPENDIX B

LINEAR Q/R LOTUS MODULE DOCUMENTATION

The Linear Q/R inventory model was written in Lotus for Windows, Version 1.1. It can be run on Lotus for DOS version 2.4 or later although the windows version is recommended. This documentation explains the computations made during model simulation. Cell formulas are presented in two ways. First, in Lotus format, but where practical, with verbal descriptions in place of actual cell locations for ease of understanding. Second, the actual cell code is included for model verification and testing. (Note: When formulas are repeated over a range of cells, only the code for the first field of the range is presented in the documentation.)
The model is organized into seven functional areas. Each major area is listed below and underlined. The range in which it appears in the spread sheet is noted in parentheses following the section name.

Section #1: DEMAND FORECASTER(M1..V42)
The demand forecaster is designed to simulate forecasts based on techniques used in UICP. Namely, it uses exponential smoothing to forecast demand, and tests for trending using the Kendall test statistic. If a trend is detected, the forecaster switches to a four quarter moving average until the trend is no longer present.

Rand:(N3..N43) Values contained in this range are generated by the Normal Random Number generator contained in the model and described later in this documentation.

Demand:(O3..O43) Demand is the integer value of the random number generated for each period. To adjust the demand downward to reflect a decrease normally experienced during equipment retirement cycles, the randomly generated demand is multiplied by the fraction of remaining population for the period being considered. The formula used is @ROUND(Random number * ((beginning population - retired equipment)/original population), - 0) **Sample Code:** @ROUND (((N3*((($V$2-(@SUM($R$3..R3)))/$V$2)))),-0)

Forecast:(P3..P43) The values appearing in this data field are taken from the Forecast Computation section of the model. **Formula:** @IF(Kendall test statistic>= Computed Kendall Value,

four quarter moving average, exponential smoothing) **Sample Code:** @IF(AC22>= $V$16,Z29,Y29)

MAD:(S84) MAD calculation is based on UICP MAD smoothing techniques. **Formula:** Smoothing constant * @ABS(demand$_{(t-1)}$ - (forecast$_{(t-1)}$)+(1 - smoothing constant) * MAD$_{(t-1)}$. **Sample Code:** $U$7* @ABS(O3-P3)+(1-$U$7)*Q3

Sked:(R3..R43) This column defines the decommissioning schedule to be used in the model simulation. To enter a decommissioning schedule run the "Problem Parameter Macro" (Ctnl I) and specify the ending equipment population and the desired decommissioning length. This macro stores the necessary information and then passes macro control to the "Decom Sked Macro" which automatically calculates a decommissioning schedule and enters it in the SKED data range.

Population:(V2) The population column indicates the equipment population for the corresponding quarter. This field is automatically computed by subtracting the decommissioned population from the previous period. **Formula:** Population$_{(t-1)}$ - Scheduled Decommission$_{(t)}$ **Sample Code:** V2-@SUM(R3..R42)

Original Population:(V3) Used to define the original equipment population for the simulation. This value is set a 500 for the simulations conducted in the thesis.

Alpha:(U5) Used to set the alpha value to be used in forecast calculations.

Prd 0 Fcst:(U6) Sets the original forecast demand value necessary to compute the period one forecast.

MAD:(U7) Sets the MAD smoothing constant for MAD calculations.

Prd 0 MAD:(U8) Sets the assumed original MAD for period 1 MAD calculation.

Lead Time:(U10) Sets the lead time (qtrs). This value is used to set the UICP Lead time parameter.

Start Linear Q/R:(U11) Indicates the period in which the Linear Q/R schedule will be implemented. In addition, it is used to identify the period of time in which to select a mean demand for the Linear Q/R schedule computation. **Formula:** Beginning Decommissioning Period - Procurement Lead Time + Linear Q/R offset value. Note, the offset value is used to change the point in time where Linear Q/R is implemented. **Sample Code:** V12 - V10 + G17

Decom Start/End Period:(V13..V14) Indicates when the decommissioning schedule begins and ends. These fields are used to calculate the total Decline Period.

Total Decline Prd:(V14) Decom period - Decom Start + 1. This value used by the Linear Q/R Macro to compute declining schedules. **Sample Code:** V13-V12+1

Kendall Critical Value: (V16) This field defines the Kendall critical value used in forecast computations.

<u>**Section #2: FORECAST CALCULATIONS(W21..AC62)**</u> This section makes the forecasting calculations.

Y:(X22..W62) Actual demand copied from the Demand Forecaster. **Sample Code:** +O3

EXP:(Y22..Y62) Forecast based on simple exponential smoothing. Alpha is a user specified value in the "Demand Forecaster" (U5). Period zero MAD is assumed to be equal to the standard deviation of demand/1.25. **Formula**: Forecast (t) = (Specified Alpha * Actual demand$_{(t-1)}$ + ((1-Alpha) * Forecast $_{(t-1)}$)) **Sample Code:** ($U$5*X23) +((1-$U$5) * P3)

4 Qtr:(Z22..Z62) Four quarter moving average. Computed by averaging four prior quarters. Formula: $(Y_{(t-4)}+Y_{(t-3)}+Y_{(t-2)}+Y_{(t-1)})/4$
Sample Code: (X26+X25+X24+X23)/4

Kendall Computations:(AA22..AA62) UICP uses the trend test based upon Kendall "s" statistic to determine if there is trend in the demand data set. As mentioned above, the Kendall technique measures how much trend is present in the demand data by examining how often recent demand values exceed or are less than older demand values. If this trend test finds enough evidence of a trend, SPCC uses a 4 quarter moving average to forecast demand rather than exponential smoothing to reduce historical forecast lags. Due to Lotus limitations in cell formula length, the computation of the Kendall "s" statistic is based on a six quarter window and is done in two parts. The first half of the computation appears in this data field. **Sample Code:** @IF(X28>X27,1,@IF(X28=X27,0,-1)) +@IF(X28>X26,1, @IF(X28=X26,0,-1)) + @IF(X28>X25,1, @IF(X28=X25,0,-1)) +@IF(X28>X24,1, @IF(X28=X24,0,-1)) +@IF(X28>X23,1, @IF(X28=X23,0,-1))+ @IF(X27>X26,1, @IF(X27=X26,0,-1))+ @IF(X27>X25,1, @IF(X27=X25,0,-1)) +@IF(X27>X24,1,@IF(X27=X24,0,-1))+ @IF(X27>X23,1, @IF(X27=X23,0,-1))

Kendall Computations: (AB22..AB62) The second half of the computation is done here. **Sample** Code: @IF(X26>X25,1,

@IF(X26=X25,0,-1))+ @IF(X26>X24,1, @IF(X26=X24,0,-1)) +@IF(X26>X23,1, @IF(X26=X23,0,-1))+@IF(X25>X24,1, @IF(X25=X24,0,-1))+ @IF(X25>X23,1,@IF(X25=X23,0,-1)) +@IF(X24>X23,1, @IF(X24=X23,0,-1))

"s": (AC22..AC62) "s" is the absolute value of the sum of the two parts of the Kendall formula. **Sample Code:** @ABS(AA29+AB29)

Section #3: INVENTORY POSITION CALCULATOR (A22..K65)
The inventory position calculator automatically calculates inventory position throughout the life cycle of a repair part. It is designed to cover 40 quarters i.e. ten total years of usage data.

Y:(B25..D65) Y is actual demand. The calculator tests the value of the demand in the forecaster and if it is greater than zero, it stores the value. If the demand is less then zero, a zero is recorded as the demand.
Formula:@if(demand>0,demand,0)
Sample Code: @IF(O3>0,O3,0)

Fcst/Mad:(C25) The forecast is copied directly from the Forecaster.

IP(prd 0):(E25) The inventory position in period zero is the sum of on hand plus on order quantities.

OH(prd 0):(F25) This value is computed by the "Period 0 OH/OO Macro." This macro uses the user specified mean demand and STD/1.25 as estimates for period zero forecast and MAD, enters the values into the UICP simulator and computes and Q and R. The OH value is then computed to be Q/2 + safety stock (taken directly from UICP simulator).

OP(prd 0):(G25) The Order Placed value is computed by the "Period 0 OH/OO Macro." The value is equal to the rounded value of mean lead time demand/EOQ multiplied by EOQ.

IP:(E26..E66) The value equal to inventory position$_{(t-1)}$, minus actual demand from period$_{(t)}$, plus the on-order quantity$_{(t)}$. **Formula:** $IP_{(t-1)}-Y_{(t)}+OO_{(t)}$. **Sample Code**: E25-B26+G26

OH:(F26..F66) Because the on hand quantity can never be a negative number, this column tests the value in hidden column L25..L65. If the number is greater then zero, the value is returned. If the number is less then or equal to zero, then zero is returned. **Formula:** @IF(OH>0,OH,0) **Sample Code:** @IF(L26>0,L26,0)

Hidden OH:(L25..L65) As stated above, L25 through L65 is a hidden field that calculates the on hand position. This value is calculated by subtracting demand$_{(t)}$ from the on-hand$_{(t-1)}$ quantity and adding on-order quantity $_{(t)}$. **Sample Code:**L26-B27+H27

OP:(H26..H65) The "order placed" column compares IP of the current quarter [IP$_{(t-1)}$-demand$_{(t)}$] to the reorder point. If IP is less than R, the program calculates the integer value of ((R$_{(t)}$-IP$_{(t-1)}$ +Y)/Q$_{(t)}$+1) (call it N) and orders N*(Q) units. Note: This value represents only the orders placed in the corresponding period. To find the total on-order quantity for the inventory position calculation, add all orders not yet received. For example, the on-order quantity for period 5 with a lead time of 2 quarters would be equal to OP$_{(period\ 5)}$ + OP$_{(period\ 4)}$. **Formula:** @IF(IP(t-1) - D(t)<R,(@INT((R(t)-IP(t-1)+Y(t))/Q(t)+1)*Q(t),0) **Sample Code:**@IF(E26-B27<K27,(@INT((K27-E26+B27)/J27)+1)*J27,0)

DUE:(H26..H65) The on-order column is used to receive orders placed in the OO column. This column sets the procurement lead time. The value shown is the quantity of the order received. **Formula:** OO(t-L) **Sample Formula:** +G26

BO:(I25..I65) Backorders are calculated by testing the on-hand quantity. If the on-hand quantity is negative, the absolute value of the on hand quantity is returned in this cell. If the on-hand quantity is greater than or equal to zero, this column defaults to zero. **Sample Code:**@ABS(@IF(L28>0,0,L28))

Section #4 Data Summary:(AS1..AU12) The summary section compiles simulation data to be saved for future analysis.

Section #5 Linear Q/R Computations: (AW23..BC76) Model Linear Q/R computations are made in this section of the spreadsheet by the Linear Q/R macro.

Q:(AX26..AX65) This cell value is computed by the UICP calculator based on the forecast and MAD for Linear Q/R implementation period.

LEOQ:(AY26..AY65) The range where the Linear Q/R macro places Linear Q/R schedule values for Q.

Final Q:(AZ26..AZ65) The final Q is the reorder quantity that is placed in the "Inventory Position Calculator". The final Q is equal to the UICP Q computation for those periods prior to the start of Linear Q/R. The final Q is equal to Q from Linear Q/R after the Linear Q/R implementation, and the UICP Q when it is less then the lowest value in the Linear Q/R

schedule. **Sample Code:** @IF(AY26=0,AX26,@IF(AY26<AX26,AY26,AX26))

R:(BA26..BA65) This cell value is computed by the UICP calculator based on the forecast and the MAD for that period.

LROP:(BB26..BB65) Space where the Linear Q/R macro places Linear Q/R schedule values for R.

Final R:(AZ26..AZ65) The final R is the reorder point that is placed in the "Inventory Position Calculator." The final R will be equal to the UICP R computation for those periods prior to the start of Linear Q/R, the value of Linear Q/R schedule after the Linear Q/R implementation, and the UICP R computation when it is less then the lowest value in the Linear Q/R schedule. **Sample Code:** @IF(BB26=0,BA26, @IF(BB26<BA26,BB26,BA26))

Section #6 UICP Simulator:(P82..AH134) This simulator approximates the wholesale inventory model used by SPCC to control inventories of consumable items. It doesn't exactly reproduce the computations that would be done by UICP, but it does represent the most important features of the UICP model. This code is obtained from Moore [Ref. 21].

Input Data: The data input fields include:

- Quarterly Demand Forecast
- Forecasted MAD for Demand
- PCLT Forecast (qtrs)
- Forecasted MAD for PCLT
- Holding Cost Rate (%/year)
- Unit Cost($/unit)
- Admin. Order Cost($/order)
- Discount Quantity (Ko)
- Quarterly Requisition Forecast
- Shortage Cost Parameter
- Shelf Life in years
- Minimum Risk Value
- Maximum Risk Value
- Probability Distribution
- Probability Break Point
- Number of Policy Receivers
- Low Limit for Reorder Point
- Essentiality Value

Simulator Calculations: The calculations of R and Q are based on the formulas presented below. The following abbreviations are used in the documentation:

Administrative Order Costs/order: A
Demand Forecast/quarter: D

Unit Cost/unit: C
Holding Cost Rate/year: I
Discount Quantity: (Ko)
Shortage Cost Parameter: K
Quarterly Requisition Forecast: F
Essentiality Code: E
Lead Time Demand: LTD
Procurement Lead Time: PLCT
Standard Deviation of Lead Time Demand: SD LTD
Mean Absolute Deviation for Demand: MAD(d)
Mean Absolute Deviation for PLCT: MAD(plct)
Shelf Life: SL
UICP final Reorder Quantity: Q
UICP final Reorder Point: R

Q Star: (T105) @SQRT((8*A*D)/(C*I}), **Cell formula:** @SQRT((8*S90*S84)/(S88*S89))

Q sub 1: (T106) @MIN((12*D), @MAX (1, Q Star, (Ko * D))), **Cell formula:** @MIN ((12*S84),@MAX(1,T105,(S91*S84)))

Risk Star: (T107) (D*I*C)/((D*I*C)+(K*F*E)), **Cell Formula:** (S84*S88*S89) /((S84*S88*S89) +(S93*S92*S101))

Risk Hat: (T108) @MIN(Max Risk, @MAX(Risk Star, Minimum Risk)), **Cell Formula:** @MIN(S96,@MAX(T107,S95))

Mean LTD: (T109) (D*PLCT), **Cell Formula:** (S84*S86)

SD LTD: (T110) @SQRT((PLCT*((1.25*MAD(d))^2))+((D*1.25*MAD(plct))^2)), **Cell Formula:** @SQRT((S86*((1.25*S85)^2))+((S84*1.25*S87)^2))

R Star: (T115) For normal distribution (Mean LTD+(Final Z Value)*SD LTD)), **Cell Formula:** (T109+(S123*T110))

Q Hat: (T114) @INT(@MAX(1,@MIN(Q sub 1,(4*D*SL-@MAX(0,(R hat-Mean LTD))))))+0.5), **Cell Formula:** @INT(@MAX(1,@MIN($T$106,(4*$S$84*$S$94-@MAX(0,($T$115-$T$109))))) +0.5)

R Hat: (T115) @INT(@MAX(Low limit for Reorder Point,@MIN((D*(4*SL+PLCT-Ko)),@MAX (@IF (Probability Distribution="Normal",R Star(normal) ,@IF(Probability Distribution ="Poisson",R Star (poisson), "Error")) ,# policy receivers)))+0.999),
Cell Formula: @INT(@MAX($S$100,@MIN(($S$84*(4*$S$94+$S$86-$S$91)),@MAX(@IF($S$97="Normal",$T$111,@IF($S$97="Poisson",$T$112,"Error")),$S$99)))+0.999)

Reorder Qty:(V84) R Hat, **Cell Formula:** @INT(@MAX(1,@MIN($T$106,(4*$S$84*$S$94-@MAX(0,($T$115-$T$109)))))+0.5)

Reorder Point: (V85) @INT(@MAX($S$100,@MIN(($S$84*(4*$S$94+$S$86-$S$91)) @MAX(@IF($S$97="Normal",$T$111,$T$112),$S$99)))+0.999)

Administrative Order Costs/year:(V89) (A*D/Q), **Cell Formula:** (S90*S84/V84)

Holding Costs/year:(V90) (Q*I*C/2)+(I*C*(R-LTD)), **Cell Formula:** (V84*S88*S89/2)+(S88*S89* (V85-T109))

Section #7: Model Macros: There are the various macros used in the model. They are placed throughout the worksheet and are described in detail in the following text. The speed keys used to start each program are listed directly after the name. In the windows version of LOTUS, the Ctnl key rather than the Alt key precedes the speed key. While the program shows Ctnl as the macro key, when operating under other then the Windows version of Lotus it must be replaced by the Alt key.

Q*/R* MACRO (Ctnl O) (A69..C231)
This macro takes the forecasts and the MADs from the "Forecaster" and places them in the UICP simulator contained in this spreadsheet. It initiates UICP calculation of Q* and R* and then copies them back to the Inventory Position Calculator.

Linear Q/R Macro (Ctnl R):(D71..N97)
This macro computes a schedule of order sizes and reorder points that decrease linearly for a number of quarters equal in length to the decommissioning cycle. To develop the schedule, the macro calculates Q and R anticipated at the end of the decommissioning cycle by reducing the forecast made at the start of the Linear Q/R implementation period indicated in cell V11. This computation is accomplished in several steps:

1) The reduced Forecast is computed in cell E92 by multiplying it by the fraction of population remaining at the end of the decommissioning cycle (V3/V2). This value is computed with the following formula: @VLOOKUP (V11,A25..K65,2)*(V3/V2). The VLOOKUP command is used to obtain the value of the forecast from the inventory position calculator.

2) The reduced MAD is computed in cell E93 by applying the power rule to the forecast in the period indicated by cell V11. (Forecast^.5*.8).

3) The Q and R values are computed by using the reduced values and by using the UICP Simulator.

4) The difference between the $Q/R_{(Implementation\ period)}$ and the anticipated ending Q/R are computed and then divided by the total number of periods included in the decommissioning cycle.

5) A schedule of the linearly reduced Q/R values is then generated and is copied into the Forecast Calculation section of the worksheet.

Random Number Generator (Ctnl D):(AG1..AP57)
A detailed explanation of the method used to generate the normal random number set is provided in the spreadsheet. The generator distribution was tested using a "Goodness of Fit" test for normal distributions. The test method used is outlined in "Statistics, Probability, Inference, and Decision (2nd edition) by Winkler and Hays, published by Holt, Rinehart and Winston (1975)
The test results are listed below:

Expected Frequency (Fe)= 50 Sample size 1000

Stand.	Norm.	Freq. Obs.	Chi^2 Cal.
-1.644853627	73.420585492	46	0.32
-1.281551566	74.873793736	48	0.08
-1.036433389	75.854266444	48	0.08
-0.841621234	76.633515064	52	0.08
-0.67448975	77.302041	48	0.08
-0.524400513	77.902397948	43	0.98
-0.385320466	78.458718136	54	0.32
-0.253347103	78.986611588	44	0.72
-0.125661347	79.497354612	49	0.02
0	80	55	0.5
0.125661347	80.502645388	57	0.98
0.253347103	81.013388412	54	0.32
0.385320466	81.541281864	60	2
0.524400513	82.097602052	51	0.02
0.67448975	82.697959	43	0.98
0.841621234	83.366484936	41	1.62
1.036433389	84.145733556	59	1.62
1.281551566	85.126206264	48	0.08
1.644853627	86.579414508	52	0.08
	Above	48	0.08
		Chi^2 =	10.96

This Chi^2 Value indicates a confidence level of 90%.

Random Number Data Set Macro (Ctnl D): (BD1..BD14)
This macro generates ten sets of random numbers following user defined mean and STD.

Copy Macro (Ctnl Z):(AW8..BD13)
This macro copies the data summary information to a separate Lotus worksheet for each simulation using the "Append right" macro command. Note: It is necessary to have a data worksheet loaded in memory to run this macro.

Problem Parameter Macro (Ctnl I):(Y9..AE23)
This macro prompts the user to provide the necessary simulation parameters. These parameters include:

- Desired Ending Equipment Population
- Period Zero Demand Forecast
- Lead time in Quarters
- Desired Length of Decommissioning Schedule
- Decom Starting Period
- Desired mean demand for random number generation
- STD of random demand

It stores simulation parameters and automatically passes control to the "Procurement Lead Time" and "Decom Sked Macro" which sets the model procurement lead time and the decommissioning schedule.

UICP Parameter Macro (Ctnl U):(Y9..AE23)
This macro prompts the user to enter the following UICP parameters:

- Unit Cost
- Admin Order Costs
- Discount Quantity
- Quarterly Requisition Forecast
- Shortage Cost Parameter
- Shelf Life (in years)
- Minimum Risk Value
- Maximum Risk Value
- Probability Break Point
- Low Limit for Reorder Point

Lead Time Setting Macro (Ctnl J):(N45..S82) This macro sets the procurement lead time to the number of periods specified in the Procurement Lead Time field. Lead time can be set directly or as one of the problem parameters set using the Problem Parameter Macro. The "Lead Time Setting Macro" is called by the Problem Parameter Macro. It can also be called directly by depressing "Ctnl J."

Decom Sked Macro: (AR29..AV52) This macro sets the decommissioning schedule in the Demand Forecaster based on a user specified ending population and decommissioning length. This macro is initiated at the end of the "Problem Parameter Macro."

APPENDIX C

Data File Summary

The following is a summary of the data obtained during the simulations conducted during this thesis research.

Perfect Forecasting Data:

Data Summary Worksheet
Datapl.wk3
Nov 3, 1992

Test Settings:
Demand Varied
STD Demand 30.00%
LT 7
Decom Length 12

Run #1 Dmd = 10	1	2	3	4	5	6	7	8	9	10
Opening IP	89	89	89	89	89	89	89	89	89	89
Demand	10	10	10	10	10	10	10	10	10	10
Std	3	3	3	3	3	3	3	3	3	3
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	76	75	118	84	77	55	70	73	94	78
Run #2 Dmd = 110										
Opening IP	831	831	831	831	831	831	831	831	831	831
Demand	110	110	110	110	110	110	110	110	110	110
Std.	33	33	33	33	33	33	33	33	33	33
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	785	1058	805	748	759	731	722	969	1,150	1,161
Run #3 Dmd = 210										
Opening IP	1,589	1,589	1,589	1,589	1,589	1,589	1,589	1,589	1,589	1,589
Demand	210	210	210	210	210	210	210	210	210	210
Std.	63	63	63	63	63	63	63	63	63	63
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,204	2,074	1,531	1,331	1,508	1,543	1,562	1,342	1,724	1,720
Run #4 Dmd = 310										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,172	1,952	2,144	2,743	2,369	2,654	2,688	2,124	1,790	1,663
Run #5 Dmd = 410										
Opening IP	3,130	3,130	3,130	3,130	3,130	3,130	3,130	3,130	3,130	3,130
Demand	410	410	410	410	410	410	410	410	410	410
Std.	123	123	123	123	123	123	123	123	123	123
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,770	2,989	2,970	3,208	2,512	3,137	2,403	3,117	3,049	3,722

Run #6 Dmd = 510										
Opening IP	3,841	3,841	3,841	3,841	3,841	3,841	3,841	3,841	3,841	3,841
Demand	510	510	510	510	510	510	510	510	510	510
Std.	153	153	153	153	153	153	153	153	153	153
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,928	4,179	3,433	4,510	5,235	3,008	3,884	3,801	3,368	3,852

Data Summary Worksheet	Test Settings:	
Datap2.wk3	Demand	Varied
Nov 3, 1992	STD Demand	30.00%
	LT	7
	Decom Length	12

Run #1 Dmd = 10	1	2	3	4	5	6	7	8	9	10
Opening IP	89	89	89	89	89	89	89	89	89	89
Demand	10	10	10	10	10	10	10	10	10	10
Std	3	3	3	3	3	3	3	3	3	3
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	69	36	75	43	58	62	79	54	61	65
Run #2 Dmd = 110										
Opening IP	831	831	831	831	831	831	831	831	831	831
Demand	110	110	110	110	110	110	110	110	110	110
Std.	33	33	33	33	33	33	33	33	33	33
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	350	526	594	514	586	636	467	543	746	714
Run #3 Dmd = 210										
Opening IP	1,589	1,589	1,589	1,589	1,589	1,589	1,589	1,589	1,589	1,589
Demand	210	210	210	210	210	210	210	210	210	210
Std.	63	63	63	63	63	63	63	63	63	63
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,143	1,261	760	862	1,035	852	855	966	1,361	1,217
Run #4 Dmd = 310										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,673	1,791	1,149	1,378	1,347	1,398	1,557	1,314	1,446	1,145
Run #5 Dmd = 410										
Opening IP	3,130	3,130	3,130	3,130	3,130	3,130	3,130	3,130	3,130	3,130
Demand	410	410	410	410	410	410	410	410	410	410
Std.	123	123	123	123	123	123	123	123	123	123
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,932	1,648	1,840	1,861	1,570	1,850	1,772	1,840	1,451	2,171
Run #6 Dmd = 510										
Opening IP	3,841	3,841	3,841	3,841	3,841	3,841	3,841	3,841	3,841	3,841
Demand	510	510	510	510	510	510	510	510	510	510
Std.	153	153	153	153	153	153	153	153	153	153
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,649	2,118	1,751	2,409	3,302	2,169	2,099	2,868	1,645	2,192

Data Summary Worksheet
Datap3.wk3
Nov 3, 1992

TestSettings:	
Demand	Varied
STD Demand	10.00%
LT	7
Decom Length	8

Run#1 Dmd=10	1	2	3	4	5	6	7	8	9	10
Opening IP	84	84	84	84	84	84	84	84	84	84
Demand	10	10	10	10	10	10	10	10	10	10
Std	1	1	1	1	1	1	1	1	1	1
LeadTime	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	43	57	61	59	39	56	39	62	55	57
Run#2 Dmd = 110										
Opening IP	803	803	803	803	803	803	803	803	803	803
Demand	110	110	110	110	110	110	110	110	110	110
Std.	11	11	11	11	11	11	11	11	11	11
LeadTime	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	499	417	480	481	419	498	441	539	471	437
Run #3 Dmd = 210										
Opening IP	1,535	1,535	1,535	1,535	1,535	1,535	1,535	1,535	1,535	1,535
Demand	210	210	210	210	210	210	210	210	210	210
Std.	21	21	21	21	21	21	21	21	21	21
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	918	791	969	1,010	1,006	985	1,047	718	1,101	884
Run #4 Dmd = 310										
Opening IP	2,245	2,245	2,245	2,245	2,245	2,245	2,245	2,245	2,245	2,245
Demand	310	310	310	310	310	310	310	310	310	310
Std.	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,201	1,446	1,049	1,154	1,487	1,127	1,183	1,329	1,130	1,310
Run #5 Dmd = 410										
Opening IP	3,026	3,026	3,026	3,026	3,026	3,026	3,026	3,026	3,026	3,026
Demand	410	410	410	410	410	410	410	410	410	410
Std.	41	41	41	41	41	41	41	41	41	41
LeadTime	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,587	1,858	1,645	2,084	1,545	1,849	1,632	1,416	1,811	1,869
Run #6 Dmd = 510										
Opening IP	3,711	3,711	3,711	3,711	3,711	3,711	3,711	3,711	3,711	3,711
Demand	510	510	510	510	510	510	510	510	510	510
Std.	51	51	51	51	51	51	51	51	51	51
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,628	1,821	1,896	2,102	2,203	1,888	2,321	1,930	1,946	1,937

Data Summary Worksheet			Test Settings:							
Datap4.wk3			Demand			Varied				
Nov 3, 1992			STD Demand			50.00%				
			LT			7				
			Decom Length			8				
Run #1 Dmd = 10	1	2	3	4	5	6	7	8	9	10
Opening IP	95	95	95	95	95	95	95	95	95	95
Demand	10	10	10	10	10	10	10	10	10	10
Std	5	5	5	5	5	5	5	5	5	5
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	69	74	132	84	76	92	101	72	88	80
Run #2 Dmd = 110										
Opening IP	859	859	859	859	859	859	859	859	859	859
Demand	110	110	110	110	110	110	110	110	110	110
Std.	55	55	55	55	55	55	55	55	55	55
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	824	955	1,022	742	798	754	808	820	699	864
Run#3 Dmd = 210										
Opening IP	1,642	1,642	1,642	1,642	1,642	1,642	1,642	1,642	1,642	1,642
Demand	210	210	210	210	210	210	210	210	210	210
Std.	105	105	105	105	105	105	105	105	105	105
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,624	1,814	1,930	1,422	1,163	1,246	1,562	1,296	1,147	1,638
Run #4 Dmd = 310										
Opening IP	2,403	2,403	2,403	2,403	2,403	2,403	2,403	2,403	2,403	2,403
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	3,505	3,016	2,500	1,857	2,299	2,361	2,178	3,053	2,190	2,721
Run #5 Dmd = 410										
OpeningIP	3,235	3,235	3,235	3,235	3,235	3,235	3,235	3,235	3,235	3,235
Demand	410	410	410	410	410	410	410	410	410	410
Std.	205	205	205	205	205	205	205	205	205	205
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	3,522	2,600	2,723	3,790	2,890	4,403	2,815	3,322	4,575	1,941
Run #6 Dmd = 510										
Opening IP	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971	3,971
Demand	510	510	510	510	510	510	510	510	510	510
Std.	255	255	255	255	255	255	255	255	255	255
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,893	4,525	3,161	3,884	4,782	3,413	3,312	3,658	4,722	4,408

Data Summary Worksheet
Datppl5.wk3
Nov 3, 1992

Test Settings:

Demand	310
STD Demand	30.00%
LT	Varied
Decom Length	4

Run#1 LT=2	1	2	3	4	5	6	7	8	9	10
OpeningIP	757	757	757	757	757	757	757	757	757	757
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
LeadTime	2	2	2	2	2	2	2	2	2	2
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	437	392	323	443	520	504	596	378	334	338
Run #2 LT=4										
Opening IP	1,413	1,413	1,413	1,413	1,413	1,413	1,413	1,413	1,413	1,413
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	4	4	4	4	4	4	4	4	4	4
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	999	879	1,055	1,321	1,268	1,330	1,348	984	943	708
Run #3 LT=6										
Opening IP	2,063	2,063	2,063	2,063	2,063	2,063	2,063	2,063	2,063	2,063
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,723	1,549	1,728	2,181	1,947	2,259	2,199	1,675	1,522	1,258
Run #4 LT=8										
Opening IP	2,710	2,710	2,710	2,710	2,710	2,710	2,710	2,710	2,710	2,710
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	8	8	8	8	8	8	8	8	8	8
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,456	2,345	2,565	3,146	2,760	3,047	3,106	2,416	2,084	1,940
Run #5 LT=10										
Opening IP	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	10	10	10	10	10	10	10	10	10	10
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	3,407	3,141	3,251	4,118	3,579	4,001	3,918	3,129	2,896	2,594
Run #6 LT=12										
Opening IP	3,999	3,999	3,999	3,999	3,999	3,999	3,999	3,999	3,999	3,999
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	12	12	12	12	12	12	12	12	12	12
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	4,368	3,948	4,058	4,934	4,397	4,800	4,768	4,099	3,698	3,145

Data Summary Worksheet		Test Settings:	
Datppl6.wk3		Demand	310
Nov 19,1992		STD Demand	30.00%
		LT	Varied
		Decom Length	12

Run #1 LT=2	1	2	3	4	5	6	7	8	9	10
Opening IP	757	757	757	757	757	757	757	757	757	757
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	262	143	167	223	209	194	196	129	188	167
Run #2 LT=4										
Opening IP	1,413	1,413	1,413	1,413	1,413	1,413	1,413	1,413	1,413	1,413
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	4	4	4	4	4	4	4	4	4	4
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	762	718	517	636	464	498	486	537	698	621
Run #3 LT=6										
Opening IP	2,063	2,063	2,063	2,063	2,063	2,063	2,063	2,063	2,063	2,063
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,363	1,388	960	1,146	930	1,007	1,204	1,114	1,180	961
Run #4 LT=8										
Opening IP	2,710	2,710	2,710	2,710	2,710	2,710	2,710	2,710	2,710	2,710
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
LeadTime	8	8	8	8	8	8	8	8	8	8
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,973	2,188	1,460	1,784	1,743	1,795	1,978	1,610	1,742	1,426
Run #5 LT=10										
Opening IP	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355	3,355
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	10	10	10	10	10	10	10	10	10	10
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,527	2,851	1,926	2,756	2,426	2,749	2,790	2,196	2,195	1,748
Run #6 LT=12										
Opening IP	3,999	3,999	3,999	3,999	3,999	3,999	3,999	3,999	3,999	3,999
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	12	12	12	12	12	12	12	12	12	12
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	3,228	3,662	2,733	3,572	3,244	3,548	3,640	2,908	2,759	2,198

Data Summary Worksheet
Datpp7.wk3
Dec 7, 1992

Test Settings:	
Demand	310
STD Demand	30.00%
LT	7
Decom Length	Varied

Run #1 Dmd = 10	1	2	3	4	5	6	7	8	9	10
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,175	1,957	2,148	2,748	2,372	2,656	2,692	2,128	1,794	1,667
Run #2 Dmd = 110										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	6	6	6	6	6	6	6	6	6	6
UICP Excess	1,788	1,600	1,802	2,394	2,097	2,350	2,400	1,771	1,453	1,330
Run #3 Dmd = 210										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,643	1,796	1,454	2,022	1,813	2,008	2,108	1,428	1,232	1,075
Run #4 Dmd = 310										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	10	10	10	10	10	10	10	10	10	10
UICP Excess	1,456	1,821	1,164	1,706	1,546	1,713	1,854	1,497	1,372	1,067
Run #5 Dmd = 410										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,675	1,795	1,153	1,381	1,352	1,402	1,560	1,318	1,448	1,149
Run #6 Dmd = 510										
Opening IP	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324	2,324
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	14	14	14	14	14	14	14	14	14	14
UICP Excess	1,671	1,659	1,066	1,430	1,042	1,107	1,258	1,263	1,440	1,289

The following is a summary of data from Linear Q/R testing.

Data Summary Worksheet	Test Settings:	
11/17/92	Demand	Varied
Datad1.wk3	STD Demand	30.00%
	LT	7
	Decom Length	4

Run #1 Dmd = 10	1	2	3	4	5	6	7	8	9	10
Opening IP	88	88	88	88	88	88	88	88	88	88
Demand	10	10	10	10	10	10	10	10	10	10
Std	3	3	3	3	3	3	3	3	3	3
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	101	86	81	81	83	77	83	95	77	71
ACWT(p)	0	0	0	0	0	0.068	0.01	0	0	0
LQ/R Excess	2	19	2	13	15	7	2	3	8	32
ACWT	0.635	0	0.418	0	0	0.068	0.304	0	0	0
Run #2 Dmd = 110										
Opening IP	822	822	822	822	822	822	822	822	822	822
Demand	110	110	110	110	110	110	110	110	110	110
Std	33	33	33	33	33	33	33	33	33	33
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	782	914	679	877	784	789	727	798	866	856
ACWT(p)	0.053	0	0	0.183	0	0	0.013	0	0	0
LQ/R Excess	2	2	2	2	29	46	2	2	2	19
ACWT	0.947	0.295	0.005	0.984	0.51	.028	.759	0.53	0.120	0
Run #3 Dmd = 210										
Opening IP	1,573	1,573	1,573	1,573	1,573	1,573	1,573	1,573	1,573	1,573
Demand	210	210	210	210	210	210	210	210	210	210
Std	63	63	63	63	63	63	63	63	63	63
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,341	1,543	1,495	1,599	1,525	1,496	1,576	1,704	1,446	1,705
ACWT(p)	0.114	0.171	0.035	0.023	0	0.005	0.009	0	0	.0726
LQ/R Excess	2	2	19	2	2	2	2	2	2	2
ACWT	0.82	1.16	0.04	0.827	0.607	0.634	0.34	0.885	0.91	1.1095
Run #4 Dmd = 310										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,671	2,035	2,202	2,487	2,680	2,898	2,267	2,281	2,079	1,969
ACWT(p)	0.262	0	0.005	0	0.383	0.016	0.37	0.047	0.016	0.0067
LQ/R Excess	2	2	2	2	2	2	2	2	2	92
ACWT	1.46	0.70	0.71	0.61	1.46	0.602	1.594	0.962	0.841	0.006

Run #5 Dmd = 410										
Opening IP	3,099	3,099	3,099	3,099	3,099	3,099	3,099	3,099	3,099	3,099
Demand	410	410	410	410	410	410	410	410	410	410
Std	123	123	123	123	123	123	123	123	123	123
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,984	3,127	3,283	2,539	2,869	3,258	2,950	2,648	2,970	3,005
ACWT(p)	0	0.458	0.442	0.164	0.017	0.102	0.010	0	0	0.0539
LQ/R Excess	2	2	2	47	2	2	2	2	2	2
ACWT	0.57	1.14	0.74	0.16	0.76	1.092	0.806	0.55	0.72	0.15

Run #6 Dmd = 510										
Opening IP	3,802	3,802	3,802	3,802	3,802	3,802	3,802	3,802	3,802	3,802
Demand	510	510	510	510	510	510	510	510	510	510
Std	153	153	153	153	153	153	153	153	153	153
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	3,400	2,909	3,371	3,593	4,159	3,178	3,985	3,469	3,380	3,127

Data Summary Worksheet	Test Settings:	
11/17/92	Demand	Varied
Datad2.wk3	STD Demand	30.00%
	LT	7
	Decom Length	12

Run #1 Dmd = 10		1	2	3	4	5	6	7	8	910
Opening IP	88	88	88	88	88	88	88	88	88	88
Demand	10	10	10	10	10	10	10	10	10	10
Std	3	3	3	3	3	3	3	3	3	3
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	83	72	62	80	62	80	60	79	78	57
ACWT(p)	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0
LQ/R Excess	1	1	1	2	2	2	2	2	2	1
ACWT	0.84	0.44	0.58	0.51	0.44	0.80	0.78	0.53	0.45	0.03

Run #2 Dmd = 110										
Opening IP	822	822	822	822	822	822	822	822	822	822
Demand	110	110	110	110	110	110	110	110	110	110
Std	33	33	33	33	33	33	33	33	33	33
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	0	0	12	12	12	12	12
UICP Excess	557	774	518	706	656	662	543	667	714	630
ACWT(p)	0.07	0.00	0.00	0.18	0.01	0.07	0.02	0.00	0.00	0.00
LQ/R Excess	1.67	2.00	2.00	1.08	2.00	1.33	2.00	1.17	2.00	1.83
ACWT	1.11	1.29	0.95	0.92	0.99	1.26	1.21	0.83	0.84	0.85

Run #3 Dmd = 210										
Opening IP	1,573	1,573	1,573	1,573	1,573	1,573	1,573	1,573	1,573	1,573
Demand	210	210	210	210	210	210	210	210	210	210
Std	63	63	63	63	63	63	63	63	63	63
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,176	1,339	1,210	980	1,275	1,209	1,183	1,300	1,133	1,397
ACWT(p)	0.09	0.13	0.03	0.05	0.00	0.00	0.00	0.10	0.00	0.10
LQ/R Excess	1.08	2.00	1.00	1.50	1.67	1.67	1.83	1.50	2.00	1.50
ACWT	1.12	1.29	0.66	1.15	0.97	0.93	1.20	1.40	1.22	1.43

Run #4 Dmd = 310										
OpeningIP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0	0.01	0.04	0.34	0.14	0.33	0.04	0.01	0
LQ/R Excess	2	1	2	2	2	2	2	2	2	1
ACWT	1.69	1.18	1.16	1.38	1.21	1.26	1.60	1.22	1.26	0.95
Run #5 Dmd = 410										
OpeningIP	3,099	3,099	3,099	3,099	3,099	3,099	3,099	3,099	3,099	3,099
Demand	410	410	410	410	410	410	410	410	410	410
Std	123	123	123	123	123	123	123	123	123	123
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,110	1,763	2,154	2,239	1,829	2,127	2,283	2,195	2,099	1,896
ACWT(p)	0.00	0.37	0.36	0.13	0.01	0.15	0.01	0.00	0.00	0.04
LQ/R Excess	1.67	1.33	1.83	1.67	2.00	1.83	1.83	1.50	1.25	1.25
ACWT	0.79	1.23	0.93	0.78	0.99	1.30	0.90	1.16	1.27	0.75
Run #6 Dmd = 510										
Opening IP	3,802	3,802	3,802	3,802	3,802	3,802	3,802	3,802	3,802	3,802
Demand	510	510	510	510	510	510	510	510	510	510
Std	153	153	153	153	153	153	153	153	153	153
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,826	2,498	2,004	2,901	3,145	2,719	2,398	3,070	2,427	2,364

Data Summary Worksheet	Test Settings:	
11/17/92	Demand	Varied
Datad3.wk3	STD Demand	10.00%
	LT	7
	Decom Length	8

Run #1 Dmd = 10		1	2	3	4	5	6	7	8	910
Opening IP	84	84	84	84	84	84	84	84	84	84
Demand	10	10	10	10	10	10	10	10	10	10
Std	1	1	1	1	1	1	1	1	1	1
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	78	78	74	58	75	61	81	77	75	80
ACWT(p)	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LQ/R Excess	1.25	1.00	1.00	1.00	1.00	1.00	1.25	1.00	1.00	1.00
ACWT	0.77	0.51	0.70	0.44	0.66	0.32	0.52	0.54	0.66	0.74
Run #2 Dmd = 110										
Opening IP	800	800	800	800	800	800	800	800	800	800
Demand	110	110	110	110	110	110	110	110	110	110
Std	11	11	11	11	11	11	11	11	11	11
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	666	543	666	711	626	720	637	748	665	564
ACWT(p)	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
LQ/R Excess	1.25	2.00	1.63	1.25	1.13	2.00	2.00	1.38	1.13	1.75
ACWT	1.13	1.08	1.27	1.26	1.05	1.22	1.01	1.23	1.26	1.15

Run #3 Dmd = 210										
OpeningIP	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530	1,530
Demand	210	210	210	210	210	210	210	210	210	210
Std	21	21	21	21	21	21	21	21	21	21
LeadTime	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICPExcess	1,249	1,156	1,243	1,253	1,158	1,240	1,198	1,086	1,304	1,252
ACWT(p)	0.00	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.00
LQ/R Excess	1.50	1.25	1.50	2.00	2.00	1.25	1.88	2.00	2.00	2.00
ACWT	1.22	1.06	1.31	1.32	1.15	1.22	1.20	1.11	0.99	1.20

Run #4 Dmd = 310										
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std	31	31	31	31	31	31	31	31	31	31
LeadTime	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	1.88	1.25	1.50	1.25	1.75	1.25	1.50	1.13	1.50	2.00
ACWT	1.11	1.27	1.16	0.84	1.22	1.21	1.15	1.28	1.18	1.20

Run #5 Dmd = 410										
Opening IP	3,016	3,016	3,016	3,016	3,016	3,016	3,016	3,016	3,016	3,016
Demand	410	410	410	410	410	410	410	410	410	410
Std	41	41	41	41	41	41	41	41	41	41
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,323	2,230	2,331	2,520	2,120	2,141	2,157	2,055	2,400	2,437
ACWT(p)	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.03
LQ/R Excess	2.00	2.00	1.75	2.00	2.00	1.38	1.25	1.75	2.00	2.00
ACWT	1.30	1.17	1.24	1.19	1.13	1.22	1.15	1.18	1.20	1.21

Run #6 Dmd = 510										
Opening IP	3,698	3,698	3,698	3,698	3,698	3,698	3,698	3,698	3,698	3,698
Demand	510	510	510	510	510	510	510	510	510	510
Std	51	51	51	51	51	51	51	51	51	51
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	3,098	2,678	3,021	2,852	2,675	2,623	3,141	3,024	2,535	2,787
ACWT(p)	0.02	0.02	0.01	0.01	0.03	0.02	0.00	0.00	0.00	0.05
LQ/R Excess	2.00	1.50	2.00	2.00	1.50	2.00	1.13	1.75	1.50	1.25
ACWT	1.19	0.99	1.27	1.24	1.09	1.02	1.40	1.13	1.12	1.14

Data Summary Worksheet	Test Settings:	
11/17/92	Demand	Varied
Datad4.wk3	STD Demand	50.00%
	LT	7
	Decom Length	8

Run #1 Dmd = 10		1	2	3	4	5	6	7	8	910
Opening IP	92	92	92	92	92	92	92	92	92	92
Demand	10	10	10	10	10	10	10	10	10	10
Std	5	5	5	5	5	5	5	5	5	5
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	97	64	46	87	83	78	87	68	81	90
ACWT(p)	0.01	0.00	0.00	0.00	0.11	0.00	0.23	0.00	0.00	0.07
LQ/R Excess	1	2	20	2	2	1	1	3	14	2
ACWT	0.71	0.00	0.00	0.84	0.58	0.55	0.74	0.00	0.00	1.04

Run #2 Dmd = 110										
Opening IP	845	845	845	845	845	845	845	845	845	845
Demand	110	110	110	110	110	110	110	110	110	110
Std	55	55	55	55	55	55	55	55	55	55
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	708	965	926	697	658	719	645	846	841	832
ACWT(p)	0.00	0.08	0.29	0.00	0.20	0.00	0.00	0.38	0.01	0.02
LQ/R Excess 2	2	2	1	2	2	2	2	2	2	
ACWT	1.12	1.10	1.53	0.60	1.16	0.92	0.56	1.49	1.40	0.89
Run #3 Dmd = 210										
Opening IP	1,616	1,616	1,616	1,616	1,616	1,616	1,616	1,616	1,616	1,616
Demand	210	210	210	210	210	210	210	210	210	210
Std	105	105	105	105	105	105	105	105	105	105
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,348	1,630	1,462	1,128	1,285	1,566	1,495	1,461	1,378	1,215
ACWT(p)	0.22	0.49	0.08	0.10	0.08	0.20	0.08	0.04	0.00	0.00
LQ/R Excess	2	2	1	1	2	2	1	2	2	2
ACWT	1.22	2.14	0.60	0.81	0.27	1.13	1.13	0.88	1.30	0.59
Run #4 Dmd = 310										
OpeningIP	2,364	2,364	2,364	2,364	2,364	2,364	2,364	2,364	2,364	2,364
Demand	310	310	310	310	310	310	310	310	310	310
Std	155	155	155	155	155	155	155	155	155	155
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,002	1,484	2,346	1,793	2,238	2,041	2,229	2,096	2,117	2,178
ACWT(p)	0.01	0.44	0.13	0.02	0.29	0.26	0.32	0.00	0.05	0.33
LQ/R Excess	2	127	2	2	2	2	2	2	1	1
ACWT	0.93	0.44	1.20	1.08	1.41	0.33	1.79	0.00	1.28	1.34
Run #5 Dmd = 410										
Opening IP	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183	3,183
Demand	410	410	410	410	410	410	410	410	410	410
Std	205	205	205	205	205	205	205	205	205	205
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,762	2,632	2,605	3,154	2,554	2,205	2,982	3,526	2,265	2,764
ACWT(p)	0.43	0.22	0.17	0.02	0.00	0.00	0.06	0.13	0.00	0.00
LQ/R Excess	2	2	1	2	2	573	1	2	2	1
ACWT	1.80	0.81	0.79	0.78	0.83	0.00	1.12	0.13	0.54	1.55
Run #6 Dmd = 510										
Opening IP	3,906	3,906	3,906	3,906	3,906	3,906	3,906	3,906	3,906	3,906
Demand	510	510	510	510	510	510	510	510	510	510
Std	255	255	255	255	255	255	255	255	255	255
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,942	2,719	2,639	3,156	2,751	2,173	2,995	3,390	2,425	2,843
ACWT(p)	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LQ/R Excess	2	1	2	2	2	1,076	2	253	2	2
ACWT	1.24	0.21	0.37	0.25	0.51	0.00	0.80	0.00	0.17	1.08

Data Summary Worksheet	Test Settings:	
11/10/92	Demand	310
Datap15.wk3	STD Demand	30.00%
	LT	Varied
	Decom Length	4

Run #1 LT=2	1	2	3	4	5	6	7	8	9	10
Opening IP	744	744	744	744	744	744	744	744	744	744
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
LeadTime	2	2	2	2	2	2	2	2	2	2
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP	824	715	767	777	707	846	698	706	643	640
ACWT(p)	0.10	0.00	0.01	0.04	0.08	0.14	0.10	0.05	0.02	0.07
LQ/R Excess	2	2	2	2	70	2	2	2	2	2
ACWT	0.12	0.07	0.06	0.14	0.09	0.21	0.12	0.07	0.05	0.11
Run #2 LT=4										
Opening IP	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	4	4	4	4	4	4	4	4	4	4
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,615	1,244	1,293	1,443	1,502	1,662	1,352	1,243	1,173	1,175
ACWT(p)	0.21	0.00	0.01	0.04	0.21	0.19	0.25	0.04	0.00	0.07
LQ/R Excess	2	2	2	1	2	2	2	2	2	2
ACWT	0.53	0.33	0.41	0.56	0.34	0.66	0.73	0.42	0.41	0.11
Run #3 LT=6										
Opening IP	2,041	2,041	2,041	2,041	2,041	2,041	2,041	2,041	2,041	2,041
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,410	1,772	1,938	2,093	2,278	2,488	2,009	1,889	1,819	1,697
ACWT(p)	0.27	0.00	0.02	0.00	0.31	0.12	0.33	0.02	0.00	0.02
LQ/R Excess	2	2	2	2	2	2	2	2	2	88
ACWT	1.36	0.63	0.64	0.54	1.13	0.70	1.46	0.69	0.58	0.02
Run #4 LT=8										
Opening IP	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	8	8	8	8	8	8	8	8	8	8
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	3,063	2,414	2,582	2,754	3,066	3,288	2,536	2,536	2,342	2,222
ACWT(p)	0.19	0.00	0.00	0.00	0.37	0.00	0.32	0.01	0.01	0.00
LQ/R Excess	2	2	2	2	2	2	2	2	2	2
ACWT	1.37	0.79	0.81	0.45	1.57	0.46	1.67	0.87	0.93	0.08
Run #5 LT=10										
OpeningIP	3,327	3,327	H			xcess		4,621	3,460	3,870
4,180 4,781	4,915	3,824	3,825	3,500	3,271					
ACWT(p)	0.00	0.00	0.00	0.00	0.24	0.01	0.00	0.00	0.00	0.00
LQ/R Excess	2	2	2	29	2	2	2	2	2	2
ACWT	0.66	0.00	1.18	0.00	2.09	0.96	0.17	1.29	0.19	0.38

Data Summary Worksheet
11/10/92
Datapl6.wk3

Test Settings:	
Demand	310
STD	30%
LT	Varied
Decom Length	12

Run #1 LT=2	1	2	3	4	5	6	7	8	9	10
Opening IP	744	744	744	744	744	744	744	744	744	744
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	640	451	274	417	416	412	529	524	392	386
ACWT(p)	0.07	0.01	0.01	0.03	0.07	0.12	0.08	0.04	0.01	0.05
LQ/R Excess	117	2	2	7	1	2	2	2	6	2
ACWT	0.08	0.07	0.04	0.13	0.07	0.20	0.09	0.05	0.04	0.12
Run #2 LT=4										
OpeningIP	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	4	4	4	4	4	4	4	4	4	4
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	1,291	984	803	965	1,027	792	1,061	1,055	811	812
ACWT(p)	0.16	0.00	0.01	0.07	0.17	0.19	0.20	0.03	0.00	0.06
LQ/R Excess	2	2	2	2	2	2	2	2	1	1
ACWT	0.44	0.26	0.28	0.51	0.20	0.68	0.41	0.29	0.32	0.37
Run #3 LT=6										
Opening IP	2,041	2,041	2,041	2,041	2,041	2,041	2,041	2,041	2,041	2,041
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,086	1,512	1,227	1,503	1,670	1,518	1,490	1,697	1,340	1,230
ACWT(p)	0.25	0.00	0.02	0.04	0.27	0.20	0.29	0.01	0.00	0.02
LQ/R Excess	2	2	2	2	2	2	2	1	2	2
ACWT	1.29	0.81	0.84	1.09	0.87	0.94	1.22	0.82	0.85	0.70
Run #4 LT=8										
Opening IP	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685	2,685
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	8	8	8	8	8	8	8	8	8	8
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,743	2,157	1,750	2,046	2,327	2,315	2,142	2,227	1,755	1,755
ACWT(p)	0.25	0	0	0.04	0.34	0.07	0.32	0.03	0.02	0
LQ/R Excess	2	2	2	2	2	2	1	2	1	1
ACWT	2.03	1.54	1.54	1.81	1.64	1.52	1.94	1.58	1.68	1.24
Run #5 LT=10										
Opening IP	3,327	3,327	3,327	3,327	3,327	3,327	3,327	3,327	3,327	3,327
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	10	10	10	10	10	10	10	10	10	10
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	3,392	2,677	2,281	2,686	2,980	2,987	2,659	2,751	2,278	2,281
ACWT(p)	0.23	0	0	0	0.32	0.04	0.29	0	0	0
LQ/R Excess	1	2	2	1	2	2	1	2	2	2
ACWT	2.82	2.47	2.49	2.53	2.57	2.54	2.67	2.13	2.57	2.22

Run #6 LT=12										
Opening IP	3,968	3,968	3,968	3,968	3,968	3,968	3,968	3,968	3,968	3,968
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	12	12	12	12	12	12	12	12	12	12
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	4,030	3,319	2,923	3,471	3,767	3,803	3,191	3,391	2,698	2,805
ACWT(p)	0.2	0	0	0	0.27	0.03	0.15	0	0	0
LQ/R Excess	2	2	2	2	1	2	2	2	2	1
ACWT	3.33	2.73	3.57	2.82	3.6	3.33	2.7	3.17	2.99	3.08

LQ/R Implementation Point Testing Data Summary

Data Summary Worksheet	Test Settings:	
LQ/R Implementation Test	Demand	310
Dat_11.wk3	STD Demand	30.00%
11/17/92	LT	7
	Decom Length	12

Run #1 T-1	1	2	3	4	5	6	7	8	9	10
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0.00	0.01	0.04	0.34	0.15	0.33	0.05	0.01	0.01
LQ/R Excess 2	1	2	2	2	2	2	2	2	1	
ACWT	1.70	1.19	1.17	1.39	1.22	1.27	1.60	1.23	1.27	0.96

Run#2 T-L+1										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0.00	0.01	0.04	0.34	0.15	0.33	0.05	0.01	0.01
LQ/R Excess	2	2	2	2	1	2	2	1	2	2
ACWT	1.32	0.79	0.80	1.05	0.76	0.92	1.23	0.81	0.84	0.66

Run#3 T-L+2										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0.00	0.01	0.04	0.34	0.15	0.33	0.05	0.01	0.01
LQ/R Excess	2	2	2	2	2	2	2	2	2	2
ACWT	0.88	0.27	0.36	0.77	0.37	0.56	0.57	0.38	0.40	0.36

Run#4 T-L+3										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
LeadTime	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0.00	0.01	0.04	0.34	0.15	0.33	0.05	0.01	0.01
LQ/R Excess	120	112	53	14	528	2	95	89	65	1
ACWT	0.31	0.05	0.02	0.35	0.34	0.57	0.36	0.07	0.08	0.14

Run #5 T-L+4										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0.00	0.01	0.04	0.34	0.15	0.33	0.05	0.01	0.01
LQ/R Excess	467	271	257	214	707	142	360	332	247	100
ACWT	0.25	0.00	0.01	0.08	0.34	0.23	0.33	0.05	0.01	0.02

Run#6 T-L+5										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.25	0.00	0.01	0.04	0.34	0.15	0.33	0.05	0.01	0.01
LQ/R Excess	747	493	451	365	1,004	323	496	492	417	283
ACWT	0.25	0.00	0.01	0.06	0.34	0.15	0.33	0.05	0.01	0.01

Data Summary Worksheet	Test Settings:	
LQ/R Implementation Test	Demand	310
Dat_12.wk3	STD Demand	10.00%
11/18/92	LT	7
	Decom Length	8

Run#1 T-1	1	2	3	4	5	6	7	8	9	10
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	2	1	2	1	2	1	2	1	2	2
ACWT	1.11	1.27	1.16	0.84	1.22	1.21	1.15	1.28	1.18	1.20

Run#2 T-L+1										
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std.	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	2	2	1	2	1	2	2	1	2	1
ACWT	0.72	0.85	0.69	0.45	0.81	0.81	0.74	0.83	0.74	0.75

Run #3 T-L+2										
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std.	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	2	1	2	2	2	1	1	2	2	1
ACWT	0.26	0.42	0.28	0.08	0.35	0.41	0.32	0.41	0.28	0.35

Run#4 T-L+3										
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std.	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	144	30	113	197	27	2	79	42	92	53
ACWT	0.00	0.01	0.02	0.00	0.00	0.01	0.02	0.01	0.00	0.00

Run #5 T-L+4										
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std.	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	411	315	429	445	279	247	335	311	375	334
ACWT	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00

Run #6 T-L+5										
Opening IP	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237	2,237
Demand	310	310	310	310	310	310	310	310	310	310
Std.	31	31	31	31	31	31	31	31	31	31
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	1,822	1,765	1,576	1,602	2,021	1,734	1,852	1,857	1,510	1,718
ACWT(p)	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00
LQ/R Excess	676	599	701	566	531	495	589	594	643	582
ACWT	0.00	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.00	0.00

Data Summary Worksheet	Test Settings:	
LQ/R Implementation Test	Demand	310
Dat_13.wk3	STD Demand	50%
11/18/92	LT	2
	Decom Length	4

Run #1 T-1	1	2	3	4	5	6	7	8	9	10
Opening IP	778	778	778	778	778	778	778	778	778	778
Demand	310	310	310	310	310	310	310	310	310	310
Std	155	155	155	155	155	155	155	155	155	155
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	706	489	824	644	720	775	735	706	871	818
ACWT (p)	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
LQ/R Excess	54	184	129	120	167	366	69	302	251	340
ACWT	0.10	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17

Run #2 T-L+1										
Opening IP	778	778	778	778	778	778	778	778	778	778
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	706	489	824	644	720	775	735	706	871	818
ACWT (p)	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
LQ/R Excess	54	184	129	120	167	366	69	302	251	340
ACWT	0.10	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
Run #3 T-L+2										
Opening IP	778	778	778	778	778	778	778	778	778	778
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	706	489	824	644	720	775	735	706	871	818
ACWT (p)	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
LQ/R Excess	199	235	365	267	362	656	292	460	472	529
ACWT	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
Run #4 T-L+3										
Opening IP	778	778	778	778	778	778	778	778	778	778
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	706	489	824	644	720	775	735	706	871	818
ACWT (p)	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
LQ/R Excess	393	362	531	415	590	656	483	585	609	689
ACWT	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
Run #5 T-L+4										
Opening IP	778	778	778	778	778	778	778	778	778	778
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	706	489	824	644	720	775	735	706	871	818
ACWT (p)	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
LQ/R Excess	476	489	694	530	720	656	610	706	742	818
ACWT	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
Run #6 T-L+5										
Opening IP	778	778	778	778	778	778	778	778	778	778
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	2	2	2	2	2	2	2	2	2	2
Decom. Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	706	489	824	644	720	775	735	706	871	818
ACWT (p)	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17
LQ/R Excess	706	489	824	644	720	775	735	706	871	818
ACWT	0.09	0.18	0.09	0.04	0.12	0.11	0.10	0.05	0.15	0.17

Data Summary Worksheet		Test Settings:	
LQ/R Implementation Test		Demand	310
Dat_14.wk3		STD Demand	50.00%
11/18/92		LT	6
		Decom Length	4

Run #1 T-1	1	2	3	4	5	6	7	8	9	10
Opening IP	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Demand	310	310	310	310	310	310	310	310	310	310
Std	155	155	155	155	155	155	155	155	155	155
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,721	1,789	2,159	1,609	2,181	1,991	1,942	1,918	2,229	2,145
ACWT(p)	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
LQ/R Excess	2	346	2	2	2	391	2	69	2	34
ACWT	0.14	0.39	0.81	0.61	1.05	0.31	1.28	0.04	0.40	1.25
Run #2 T-L+1										
Opening IP	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,721	1,789	2,159	1,609	2,181	1,991	1,942	1,918	2,229	2,145
ACWT(p)	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
LQ/R Excess	18	932	2	2	2	796	2	69	2	30
ACWT	0.00	0.39	0.40	0.42	0.41	0.31	0.57	0.04	0.23	0.63
Run #3 T-L+2										
Opening IP	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,721	1,789	2,159	1,609	2,181	1,991	1,942	1,918	2,229	2,145
ACWT(p)	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
LQ/R Excess	18	1,652	284	81	315	1,070	181	435	75	267
ACWT	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
Run #4 T-L+3										
Opening IP	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,721	1,789	2,159	1,609	2,181	1,991	1,942	1,918	2,229	2,145
ACWT(p)	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
LQ/R Excess	184	1,652	686	432	871	1,340	306	807	323	517
ACWT	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
Run #5 T-L+4										
Opening IP	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
Lead Time	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	1,721	1,789	2,159	1,609	2,181	1,991	1,942	1,918	2,229	2,145
ACWT(p)	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
LQ/R Excess	656	1,789	958	904	1,141	1,474	675	932	655	761
ACWT	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30

Run#6 T-L+5										
Opening IP	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100	2,100
Demand	310	310	310	310	310	310	310	310	310	310
Std.	155	155	155	155	155	155	155	155	155	155
LeadTime	6	6	6	6	6	6	6	6	6	6
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICPExcess	1,721	1,789	2,159	1,609	2,181	1,991	1,942	1,918	2,229	2,145
ACWT(p)	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30
LQ/R Excess	1,036	1,789	1,357	1,024	1,272	1,604	1,050	1,416	1,173	1,253
ACWT	0.00	0.39	0.12	0.00	0.36	0.31	0.30	0.04	0.00	0.30

Data Summary Worksheet
12/04/92
Data17.wk3

Test Settings:

Demand	310
STD Demand	30%
LT	7 Qtrs
Decom Length	varied

Run #1 dc=4	1	2	3	4	5	6	7	8	9	10
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	4	4	4	4	4	4	4	4	4	4
UICP Excess	2,674	2,034	2,230	2,480	2,680	2,898	2,267	2,281	2,079	1,969
ACWT(p)	0.26	0	0.015	0	0.38	0.02	0.37	0.047	0.021	0.011
LQ/R Excess	2	2	2	2	2	2	2	2	2	92
ACWT	1.465	0.709	0.718	0.61	1.465	0.60	1.594	0.962	0.841	0.0067

Run #2 dc=6										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	6	6	6	6	6	6	6	6	6	6
UICP Excess	2,561	2,040	2,110	2,391	2,547	2,595	2,101	2,180	1,981	1,867
ACWT(p)	0.267	0	0.008	0.0	0.378	0.06	0.371	0.051	0.015	0.006
LQ/R Excess	2	2	2	2	1	2	2	2	2	2
ACWT	1.808	1.199	1.15	1.094	1.591	1.001	1.875	1.384	1.307	0.370

Run #3 dc=8										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	8	8	8	8	8	8	8	8	8	8
UICP Excess	2,430	1,979	1,890	2,154	2,404	2,395	1,934	1,962	1,646	1,847
ACWT(p)	0.259	0	0.009	0.019	0.368	0.109	0.359	0.049	0.014	0.015
LQ/R Excess	2	2	1	1	1	1	2	1	2	2
ACWT	1.84	1.3	1.346	1.497	1.468	1.338	1.829	1.407	1.385	0.85

Run #4 dc=10										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	10	10	10	10	10	10	10	10	10	10
UICP Excess	2,371	1,964	1,601	1,970	2,137	2,100	1,802	1,791	1,570	1,630
ACWT(p)	0.254	0	0.01	0.032	0.357	0.128	0.348	0.049	0.013	0.054
LQ/R Excess	2	1	2	2	2	1	2	2	2	1
ACWT	1.772	1.202	1.236	1.48	1.301	1.298	1.697	1.323	1.343	0.921

Run #5 dc=12										
Opening IP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom.Lenght	12	12	12	12	12	12	12	12	12	12
UICP Excess	2,354	1,896	1,496	1,779	2,072	1,928	1,748	1,967	1,600	1,502
ACWT(p)	0.252	0	0.01	0.042	0.342	0.148	0.333	0.047	0.013	0.005
LQ/R Excess	2	1	2	2	2	2	2	2	2	1
ACWT	1.695	1.188	1.166	1.388	1.22	1.27	1.602	1.226	1.27	0.96

Run #6 dc=14										
OpeningIP	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300	2,300
Demand	310	310	310	310	310	310	310	310	310	310
Std.	93	93	93	93	93	93	93	93	93	93
Lead Time	7	7	7	7	7	7	7	7	7	7
Decom. Lenght	14	14	14	14	14	14	14	14	14	14
UICP Excess	2,324	1,607	1,517	1,595	1,762	1,634	1,683	1,780	1,690	1,390
ACWT(p)	0.247	0	0.01	0.057	0.328	0.161	0.317	0.045	0.011	0.00
LQ/R Excess	2	2	2	1	1	2	2	2	1	1
ACWT	1.58	1.076	1.113	1.315	1.118	1.181	1.55	1.144	1.185	0.916

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